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IN THIS ISSUE . . .

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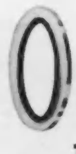

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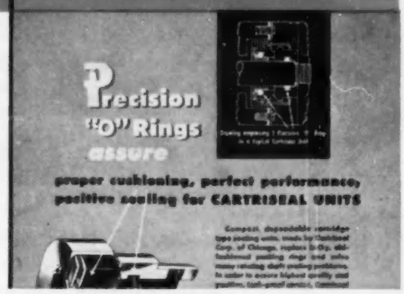

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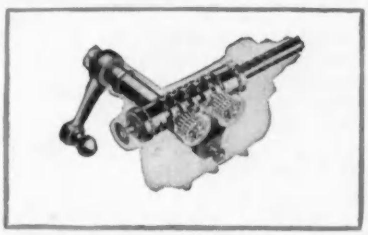
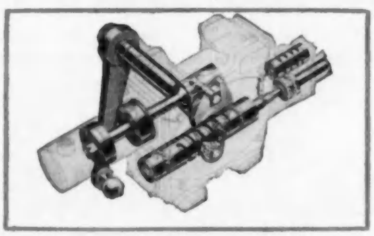
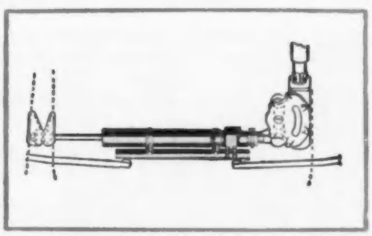

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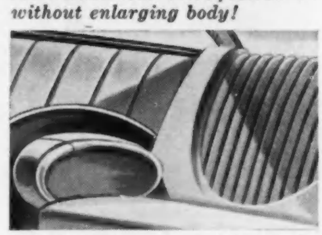

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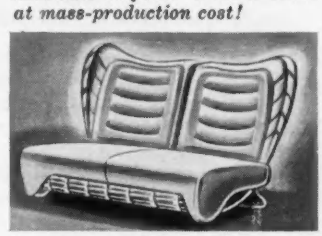

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For the Sake of Argument

Understanding . . .

By Norman G. Shidle

There is considerable evidence that the best way to be understood is to be understanding.

Understanding is what we'd like everybody to be of us; what we like to think we are of others. Trying to make ourselves understood keeps us so busy, though, it's hard to find time to do our best job of understanding others.

Rule 1 in "How to Win an Argument," according to Professors Busse and Borden of New York University, is: "Listen to the other man's opinion before you answer him." If you don't, they say, he will stop listening, no matter how good your argument. He will become preoccupied with what *he* wants to say. He won't have time to understand you, in other words, until he *thinks* he has made you understand him.

Experience indicates that knowledge can't be imparted. It can only be acquired. So, unless others actually take your points of view or your concepts, we can never hope to be fully understood. Our best course is to help others to buy; not try harder to sell.

Forced feeding results in regurgitation oftener than in digestion. Yet, only through digestion can knowledge become strengthening and useful. So with understanding, by which knowledge becomes a permanent, working part of one's consciousness.

"True conviction," R. O. Eastman says, "begins in doubt, and only as doubts are dispelled is conviction established." Much true understanding of people and programs has begun in doubt, too—and later become understanding by the very process of doubt-resolving. We help others to understand when we welcome their doubts.

Thinking and speaking in terms both clear and acceptable to others is no small part of being understanding—as well as of being understood.

"Except ye utter by the tongue words easy to be understood, how shall it be known what is spoken? for ye shall speak into the air." So warned the Aspostle Paul, who "had rather speak five words with my understanding, that by my voice I might teach others also, than ten thousand words in an unknown tongue."

To be understood and to be understanding call for constant, continuous clarity of both the mind and the emotions.

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Contents—October, 1954

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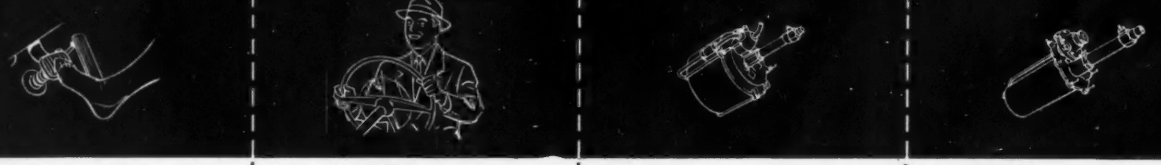
Today's most wanted power features for cars and trucks



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Researchers Marshal Combustion Study Weapons to Arrest

Power-Robbing Preignition

TECHNICAL problems seem to run in cycles, and preignition is a case in point. Twenty and even 40 years ago, internal combustion engines suffered acutely from knock and preignition. Today, the ghost of yesteryear, particularly preignition, has come back to haunt the high compression engine. Petroleum and engine researchers are going all out to get rid of the preignition bugaboo.

1. Preignition Puzzles Researchers

The preignition phenomenon is sapping the strength of modern high output powerplants, robbing them of their full pontential of power output. Ask the specialists why they don't correct the condition by modifying fuels or lubricants, or by engine redesign, and here's what they'll tell you: "We know so little about this uncontrolled type of combustion . . . we can't readily explain its behavior, its mechanism, or its effect. This thing we call preignition is erratic, elusive, and exasperating. So until we find out lots more about the parasite, we can't come up with ways of circumventing it."

The job ahead is a three-part one. Here is what it consists of:

1. To define preignition. Even the experts don't agree among themselves as to what preignition is. Attempts are under way to clarify and unify the terminology. (See page 46 for the CRC report that aims at standardization of preignition terms.)

2. To devise a test procedure that can measure preignition in all its forms and disclose its behavior and effects on engine performance.

3. To alleviate or eliminate the harmful effects of preignition on engine performance.

Parts 1 and 2 are pretty much interrelated. You can't come up with a common language unless you know just what you're talking about.

That's the reason the emphasis today in the pre-

ignition area is on instrumentation and test techniques. Engine and petroleum researchers are devising and refining techniques for coming up with an answer to the question "What is this thing called preignition?" They're putting commercial and test engines through their paces, in the laboratory and on the road. Some researchers aim at trapping preignition, in all its guises, in its natural environment. Others are first trying to simulate the phenomena. They feel that initially this will give them better, more exacting control of the variables involved. It's easier than catching a transient occurrence on the fly, they say.

From laboratories all over the country are coming reports of these new methods using modern electronic and precision equipment. Particularly encouraging are the fragmentary, cautiously worded findings on the character of preignition. Admittedly inconclusive at present, these results are beginning to come in like unrelated pieces of a jigsaw puzzle, but eventually the pieces will begin to fit together.

2. Dragnet of Researches Yields Clues on Culprit

These reports from various laboratories probably show no established pattern on the nature of preignition as yet. But they do point up lots of interesting clues and facts.

For instance, GMC's Research Laboratories Division ran some tests in a car on the road. The GM investigators found two kinds of deposit-induced abnormal ignition—continuous or sustained abnormal combustion and scattered or isolated abnormal explosions.

Tests showed that the continuous type was directly affected by fuel octane number. Removing a portion of the combustion chamber deposits eliminated the sustained abnormal combustion. Fuel octane number had no significant effect on the scattered explosions. But deposit removal was equally as effective as with the continuous variety.

Why was octane quality effective with the first type of abnormal combustion and ineffective with the second? The explanation depends on speculation concerning the mechanism of scattered abnormal explosions, say GM researchers. It goes something like this:

Suddenly operating at full load an engine containing heavy combustion chamber deposits will remove these deposits from the engine. In the removal process, loose deposit particles form. Sometimes these particles have enough energy to ignite the fuel-air mixture, regardless of fuel octane number. This kind of deposit-ignition tends to be occasional because of the random nature of the particles.

Then too, continue the GM engineers, you have to recognize the three ways in which fuel octane number affects abnormal combustion. It does so by controlling:

1. Amount of spark knock. Spark knock could cause abnormal combustion by loosening deposit particles and by increasing heat rejection to the combustion chamber surfaces.

2. Amount of precombustion reactions. These reactions would tend to form compounds of poorer ignition resistance than that of the original fuel. That would cause abnormal combustion.

3. Amount of surface reaction. Surface reaction adds much heat to deposits and that induces abnormal combustion.

These three factors, which octane number controls, don't depend on random deposit effects. They're more likely to cause sustained abnormal combustion rather than the random deposit effect alone. So you can see how this reasoning tends to explain the test findings . . . that fuel octane number affects the continuous abnormal combustion, but not the scattered type.

Standard Oil Development Co. focussed on another phase of the abnormal combustion problems and came up with some equally interesting findings on octane quality effects. In this case, surface ignition came in for scrutiny. Surface ignition is defined as "the initiation of a flame front by any hot surface before the arrival of the normal flame fronts." A simulated surface ignition source was used in these studies.

Test results showed that spark-plug timing is the chief factor in determining the amount of octane quality increase needed to suppress surface ignition-induced knock. Surface ignition can create greater changes in octane requirement with spark timing retarded from peak power than with an engine timed for peak power development. That's particularly important for this reason: Most modern engines operate with retarded spark timing during critical periods of operation.

Another interesting fact discovered was that surface ignition doesn't always reduce engine power output. Sometimes it can increase it. With the spark plug set at peak power timing, only a power decrease can result from surface ignition. But surface ignition can substantially boost power with retarded spark timing.

Surface ignition doesn't have to precede normal

The Authors

This article is based on the ideas in the papers presented at the preignition symposium at SAE Summer Meeting, Atlantic City, June 10, 1954. The papers and their authors are as follows:

- **Correlation of Engine Noises with Combustion Phenomena**
  by Robert Meagher, R. L. Johnson, and K. G. Parthemore, E. I. duPont de Nemours and Co., Inc.
- **Practical Yardstick for Deposit Effects**
  by C. A. Hall, J. A. Warren, and J. D. McCullough, Ethyl Corp.
- **A New Engine Analyzer**
  by E. A. Martin and J. H. Goffe, Socony Vacuum Laboratories
- **The Observation of Automotive Preignition and Knock**
  by R. C. Bowers, and A. R. Isitt, Shell Development Co.
- **Detection of Abnormal Flame Fronts in Road Tests with an Engine Using Independent Ionization Gaps**
  by J. R. Landis, General Motors Corp.
- **The Effect of Simulated Surface Ignition on Engine Performance**
  by L. B. Shore and J. F. Kunc, Jr., Standard Oil Development Co.
- **Controlling Preignition by Deposit Removal**
  by H. W. Sigworth and R. K. Stone, California Research Corp.

These papers are available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ each to members, 60¢ each to nonmembers.

ignition to affect performance significantly. It can make itself felt after spark firing as well.

Investigators at duPont's petroleum laboratory came up with test results closely related to those recorded at GM and Standard Oil Development. For instance, any engine noise with a clean engine comes from knock following normal combustion. These men found no evidence of unusual ignition, such as preignition.

But after their laboratory engine accumulated deposits, practically every fuel failure leading to engine noise stemmed from surface ignition which led to knock. And that came when operating with fuels closely satisfying engine requirements.

They also found that rumble was a repetitive pattern of single or multiple surface ignition coming before or after the spark. The noise probably resulted from deflections of some part of the engine structure induced by high rates of pressure rise. A clean engine didn't rumble.

Although current combustion studies aren't designed to come up with final answers to the abnormal combustion problems, they're producing some good clues. For example, Ethyl Corp.'s deposit studies brought out some interesting evaluations of present-day fuels and engine oils.

Take current refinery trends to increase the aromatics in gasolines. (That's to boost antiknock quality.) These aromatics lead to formation of combustion chamber deposits which have greater deposit-ignition tendencies. This trend further emphasizes the need for better lubricating oils and/or special fuel additives.

On the other hand, both commercial phosphorus fuel additive and the new volatile multigrade oils reduce deposit ignition.

If there's any one area of agreement amongst the specialists, it's on this one point: Deposits impair normal combustion. Starting with this premise, California Research has reasoned that if no one knows yet how to prevent deposits, then remove them when they do build up. Result: a carbon removal process—called PDQ Carbon Remover—which burns out the carbon. The treatment does point up the power-robbing qualities of deposits. Some 70 to 80% of the power loss due to deposits usually is restored in engines given this new treatment.

Equally as interesting as these findings are the test methods and devices being developed to explore abnormal combustion phenomena. The descriptions and illustrations that follow briefly describe some of them.

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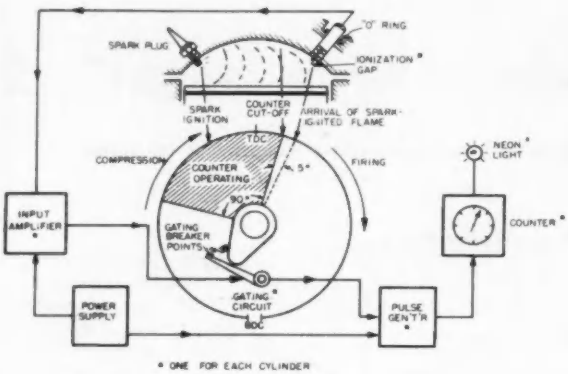
3. Varied Research Weapons Join Preignition Probe

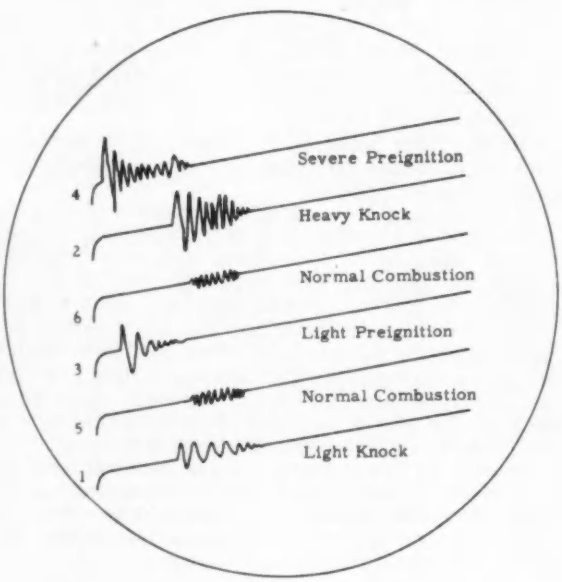
Ethyl's Multicylinder Deposit-Ignition Counter



This device automatically detects and counts uncontrolled combustion arising from ignition by the deposits. The counter differentiates this abnormal combustion from the normal.

As shown in the accompanying diagram, the equipment consists of an electronic circuit, an electro-mechanical recording counter, a camshaft-driven timing device, and an ionization gap in the combustion chamber. Differentiation is made between normal and uncontrolled combustion by making the counter operate only during a selected portion of the engine cycle before the normal spark-ignited flame front reaches the ionization gap.

The diagram shows the relative location of the spark plug and the ionization gap, and the portion of the engine cycle in which deposit ignition is recorded. Deposit-ignition rates determined by this equipment are referred to as total deposit-ignition rates. That's because the counter doesn't distinguish between either inaudible or audible deposit ignition.

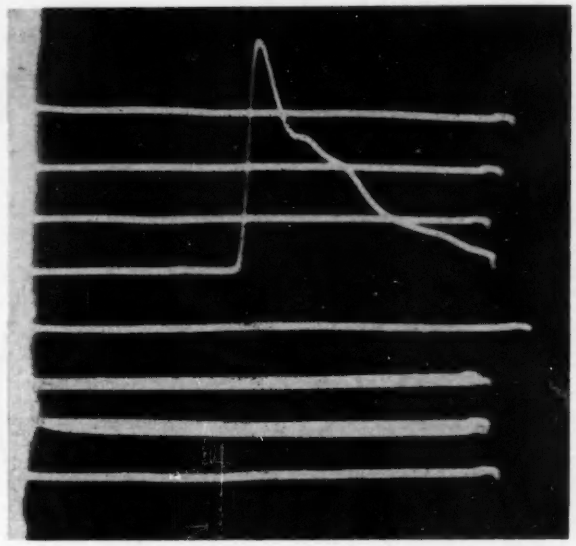


Shell's Knock Analyzer

The multicylinder knock analyzer used at Shell Development labs is basically a sweep pattern generator, used with a cathode ray oscilloscope. To permit identification of preigniting or knocking cylinders, individual sweep patterns for each cylinder are shown on the screen. The drawing at right shows the interpretation of oscilloscope patterns.

To record the transient preignition phenomenon, tape recordings of the oscilloscope signals are made on a recording translator and played back for further study. For more detailed evaluation of selected sections of the test, photographs are made of the oscilloscope pattern from the played back tape. A simple strip camera is used.

Socony-Vacuum's Engine Analyzer



Like the Shell instrument, this one too is an oscilloscope, automatically synchronized to engine crankshaft position. It furnishes visual dynamic patterns on the face of the cathode ray picture tube. Transducers are used to convert engine performance factors to an equivalent electrical voltage or current signal.

Many engine operating characteristics can be studied. Preignition and electrical ignition operation are its largest fields of application. It has been used both in the laboratory and on the road for noting the presence and extent of preignition. The illustration at right is the type of a signal shown by the Analyzer for preignition in cylinder number 8 of an 8-cyl in-line engine. The preignition occurred at about 10 deg advance.

DuPont's Correlation of Noise and Combustion Phenomena

DuPont has equipment that its researchers use to correlate changes in the combustion process due to abnormal ignition with resulting engine noises. The test setup consists of a modern-type high compression ratio car engine equipped with rate of pressure change (dp/dt) pickups in each cylinder.

Several oscilloscope screens (showing the dp/dt signal from each cylinder) are photographed simultaneously. At the same time, a sensitive microphone placed near the engine picks up abnormal noises produced by the engine.

The illustration below is that of simultaneous oscilloscope traces of the rate of pressure change (top and bottom traces) and engine noise (center trace). In this case, the combustion in cylinders 6, 5, and 4 is normal; autoignition was occurring in cylinder 3 without apparent noise, as indicated by the normal sound trace; in cylinders 8 and 7 the autoignition was severe enough to produce a high frequency noise or knock on the sound trace.

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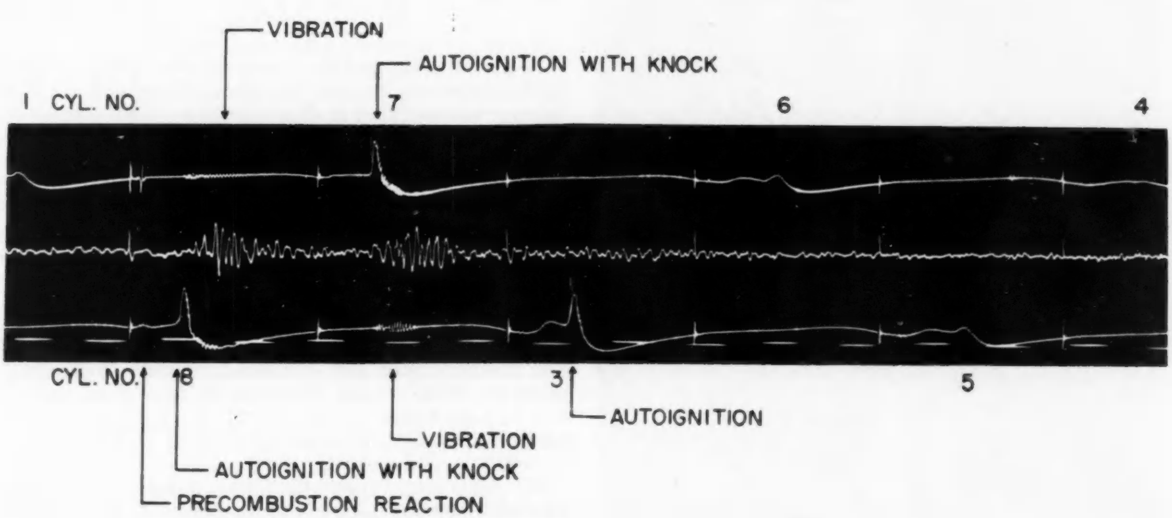
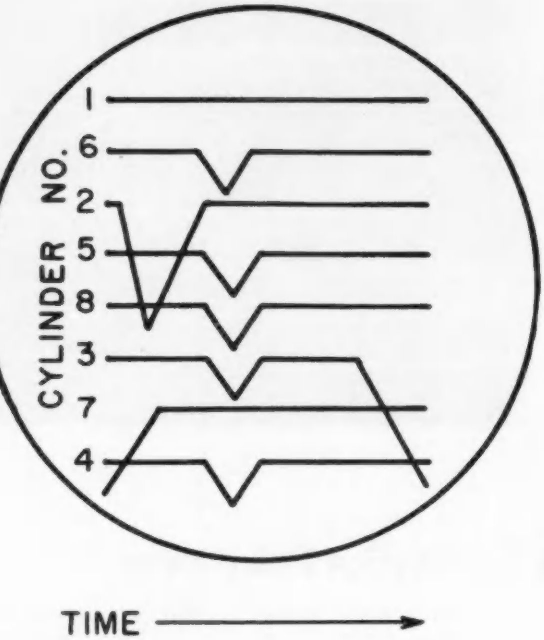


GM's Use of an Ionization Gap



In its laboratory equipment, GM Research Laboratories Division has fitted the production cylinder head of a 1953 8-cyl engine with a second spark plug. This plug serves as an ionization gap in each cylinder except No. 1. Each ionization gap is placed on the transverse centerline of the cylinder about 3 in. from the normal spark plug. The seven ionization gaps are connected in parallel to a 67-v d-c battery, which in turn is connected to the y-axis of a Socony-Vacuum engine analyzer oscilloscope (mentioned above).

The x-axis of this oscilloscope is driven by the firing of the normal spark plugs so that the horizontal sweep returns to the starting point each time a plug is fired. The oscilloscope also permits vertical separation of the traces so that events in individual cylinders can be compared. Therefore, each horizontal trace represents the 90 deg of crankshaft rotation following spark ignition for a particular cylinder in the 8-cyl engine. The accompanying diagram depicts the oscilloscope indication of abnormal combustion in cylinders 2 and 7 . . . the flame arrived at the ionization gap earlier than normal.

Standard Oil Development's Surface Ignition Simulation

In its studies on the effect of simulated surface ignition on engine performance, Standard Oil Development has used a single cylinder CFR overhead valve engine. An independently timed second spark plug simulates surface ignition. (See diagram for arrangement in CFR engine combustion chamber.)

The simulated ignition surface source is located 135 deg around the chamber from the spark plug. A second set of independently timed ignition points and an ignition coil produce the second ignition source. The pressure indicator shown in the diagram determines combustion chamber pressure. Resistance change in the strain gage elements of the pressure indicator creates a change in the balance condition of an electrical bridge. The resultant voltage change at the bridge output terminals is amplified and appears as a function of pressure on an oscilloscope screen.

In determining combustion chamber pressures, the oscilloscope signal is photographed with a strip film oscilloscope camera.

The Evolution of the Turbo Compound

F. J. Wiegand and W. R. Eichberg,
Wright Aeronautical Division of Curtiss-Wright Corporation

Based on paper "Development of the Turbo Compound Engine" presented at the SAE Annual Meeting, Detroit, Jan. 13, 1954. This paper will be printed in full in the 1954 SAE Transactions.

THE Wright Turbo Compound engine now powering DC-7 and Super Constellation airliners has evolved through tens of thousands of hours of experimental testing from the C18 engine that powered B-29 bombers during World War II.

Improvements in the basic engine have raised take-off power to 2750 bhp. Addition of three turbines which recover energy from the exhaust and return it to the crankshaft contribute another 500 or more hp at take-off. Fuel economy benefits both from recovery of exhaust energy and from direct cylinder-head fuel injection.

Development testing of the Turbo Compound started in 1947. Production engines began to roll off the assembly line in March 1950. First users were the Lockheed P2V Neptune patrol bomber, the Martin P5M Marlin flying boat, and the Fairchild C-119 Flying Van cargo transport.

Development work continued as flying experience piled up. The current, well matured version is being turned out on automated assembly lines to power transports ordered by over a score of airlines, both domestic and foreign.

Here are details on a few of the many steps in the evolution of the Turbo Compound:

The Turbo Compound cylinder was developed from the C18BD1 forged cylinder, which is presently operating with good durability up to 10,000 hr in airline service. Improvements include generous radii at stress concentration points, more cooling fin area, and additional attaching threads. The cooling fin area has been increased about 40% on an overall basis, with local areas on the head receiving as much as a 200% increase in fin cooling area.

These increases have resulted in a generally lower average temperature at the seat locations with significant improvement in performance. Naturally, these changes result in increased weight. The 18 cylinders on the Turbo Compound weigh approximately 110 lb more altogether than those on the C18BD engine.

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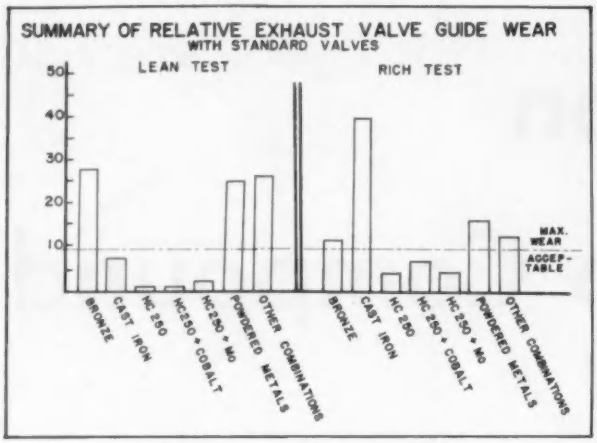
Turbo Compound Cylinder



Development of the present **exhaust valve guide** is the result of approximately 13,000 hr of single-cylinder testing. Some 80 combinations of stem and guide materials and configurations were investigated or tested.

Early in the course of this investigation the mixture strength was found to have a profound effect on guide wear. Dezincification was found to be the cause of excessive wear of bronze guides when lean fuel/air mixtures were used. Wear of bronze guides at rich mixtures was low. However, with most cast irons, including many high-alloy irons such as Ni-Resist 1A, rich-mixture operation caused excessive wear.

The present HC-250 guide material is a high-carbon (2¾%), high-chromium (25%) cast structure bordering on tool steel analysis. With this, little wear of either the guide or valve stem was encountered, regardless of mixture strengths.

During the development of HC-250 guides, they were found to be somewhat incompatible with soft stem valves, including shot peened Inconel "M". Colmony 6 coated stems were fairly successful on experimental test, and service testing is proceeding to evaluate this combination.

Experimentally, other stem treatments are being tested in conjunction with HC-250 guides and other guide materials are being investigated for resistance to wear during both rich and lean operation.

Since the developed shaft horsepower in the Turbo Compound has been increased by improvement to the basic engine and the addition of the three exhaust turbines, it was necessary to increase the strength of the crankshaft assembly. Preliminary testing indicated that maximum stresses were induced in the crankshaft by engine-induced vibrations with the natural frequencies found at or near take-off rpm.

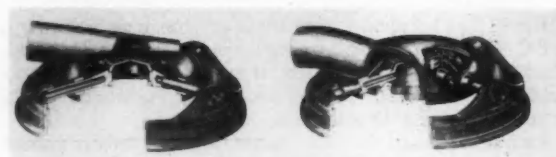
To raise the natural frequency of the crankshaft, material was added to the center crankcheek. In addition, the rear crankcheek thickness was increased to strengthen and stiffen this member of the assembly.

The **cooling system of the turbine** uses ram air, ducted from the front of the engine and introduced into the turbine through an enclosing muff. An impeller installed on the main shaft provides the necessary pressure rise to force the air through holes at the base of each wheel bucket. The air is collected on the outlet side by a shield assembly and discharged into the exhaust outlet. Sealing between the exhaust gas and the cooling air is accomplished by a concentric groove labyrinth seal on the underside of the cooling air impeller and by a step-type seal on the upper side of the wheel.

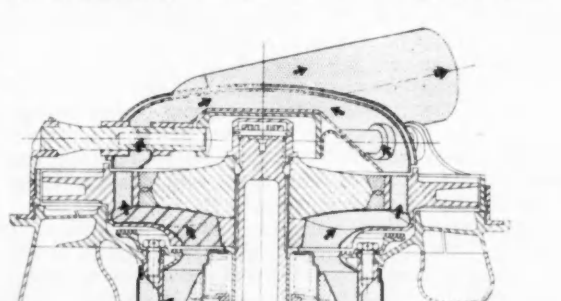
Recently, marginal turbine wheel hub cooling was encountered during high-power operation at high altitude. In one particular installation, it was found that the pressure differential between the exhaust system and the cooling system increased at high altitude and disturbed the flow of air above the wheel.

This condition was improved somewhat by modifications to the flight hood. Also a tangential outlet was provided to minimize the back pressure on the cooling impeller. To reduce exhaust gas leakage into the cooling air system a vent arrangement was incorporated at the step-type seal on the upper side of the wheel. Exhaust gas was drawn off in an outlet concentric with the cooling air outlet to avoid dilution of the cooling air above the wheel. An inner heat shield was also provided to reduce the effect of radiant heat on the wheel hub. This modification resulted in 100% improvement in cooling at

Cooling system of the turbine



CENTER OUTLET DESIGN COOLING AIR SHIELD   CONCENTRIC TANGENTIAL OUTLET COOLING AIR SHIELD



18,000 ft altitude and permitted satisfactory operation under any power condition in the airplane.

Since there are a number of exciting frequencies generated by both the engine and the turbine gas forces, it was necessary to develop a **damping system** which would prove effective for all orders and have a reasonable weight.

This was done by designing the turbine support structure as a spring. It is a pedestal on a spring diaphragm permitting the turbine wheel, within the limitations of the spring, to move slightly in all radial directions. The upper end of the pedestal was equipped with a plate-type friction damper in which half the plates were fixed to the nozzle support and half the plates were fixed to the pedestal.

Loading was provided between the plates by eight springs compressed to a predetermined load. Since relative motion is allowed by this means and damping is present, vibratory gas forces coming through the wheel or engine-excited forces transmitted through the case cannot excite resonant vibration over the entire operating range of the engine.

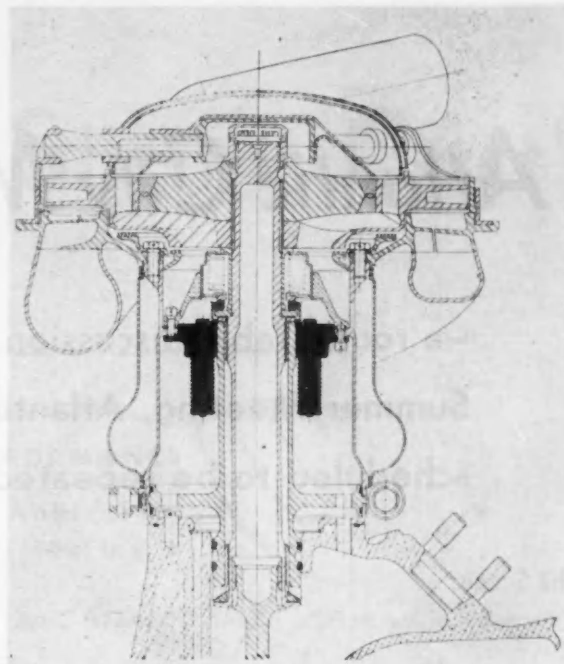
To isolate the torsional vibrations inherent in the power recovery system from those inherent in the basic engine, a **fluid coupling** was provided in the drive system. This coupling prevents any build-up of forces in the drive system excited by torsional vibration and permits the use of a light-weight drive system. To avoid complications in the lubricating system, engine oil is used in this coupling.

Early in service operations it was evident that despite the high-velocity circulation of oil within the fluid coupling, the quantity of oil flow through the coupling was insufficient to flush completely the low-velocity discharge area. Sludge accumulated there. This locked the two elements of the fluid coupling. The resulting torsional excitation of the drive adversely affected its durability.

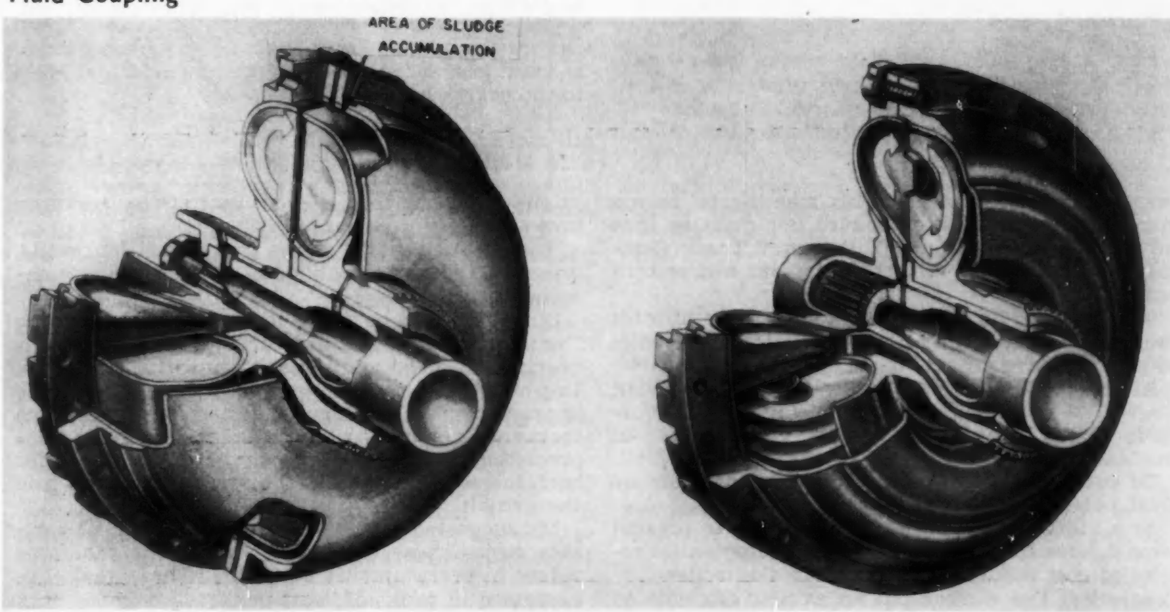
Increasing the oil flow and improving the cleaning of the airplane oil system improved the service life, but did not completely eliminate the accumulation of the sludge. As further insurance against sludge accumulation, several configurations were developed which by mechanical means prevented formation of sludge in the low-velocity area. The most desirable configuration was the vortex-flushed fluid coupling which is currently incorporated in the engine.

This coupling utilizes the high-velocity stream of oil circulating within the coupling to flush the area of potential sludge accumulation.

Damping System



Fluid Coupling



"Atlantic City Motor Truck Co."

—a round table discussion staged as a drama at SAE Summer Meeting, Atlantic City, June 8, 1954 and scheduled to be repeated at next Annual Meeting.

The Scene:

Boardroom of the mythical Atlantic City Motor Truck Co.

The Time:

Three weeks after trade papers had carried news of price cuts announced by manufacturers of competitive trucks

The Characters:

The top managment team of the Atlantic City Motor Truck Co., including its

President
Controller
Purchasing Agent
Factory Manager
Chief Engineer
and their chief lieutenants

The Players:

J. E. Adams, director of purchases & planning, White Motor Co.
W. R. Bunge, supervisor of budgets, Allis-Chalmers Mfg. Co.
R. E. Cross, executive vice president, The Cross Machinery Co.
L. E. Cummings, assistant manager of production and material control, Delco Products Division
C. L. Hecker, first vice president, The Oliver Corp.
J. F. Jones, factory manager, Hudson Motor Car Co.
M. F. Macaulay, general factory manager, Packard Motor Car Co.
T. H. Morrell, chief engineer, The Oliver Corp.
F. J. Zielsdorf, plant manager, A. B. Farquhar Division of The Oliver Corp.

The Credits:

C. L. Hecker served as chairman for the round table and laid the ground work for the skit. F. J. Zielsdorf served as round table secretary and provided the report on which the accompanying script is based.

President: The purpose of this meeting is, as you know, to discuss ways to reduce our costs so that we can keep the Atlantic City Motor Truck Company's prices in line with those of our midwestern competitors.

We are going to have to trim our prices to meet theirs. That's our only hope of regaining the sales volume we have already lost to them.

At the same time we must maintain our profit levels. We've had an unbroken record of good profits for the last 10 years, and we're going to keep in the black.

To cut prices and maintain profits, obviously we must cut costs.

As a starter, I've asked our controller to present some figures that will help us measure potential results of cost reduction efforts. Mr. Controller.

Controller: I've worked out an exhibit (Exhibit A) in the form of a break-even analysis to show you how we might meet our objective.

You'll notice that it shows past operating results, present fixed and variable cost factors, and recommended cost goals.

Since this is to be a rather far-reaching program, I've assumed that Manufacturing and Design Engineering will need additional technical staff people. I've assumed also that our program will embrace improvements in tooling and cost-reducing machine tools and equipment which will entail increased depreciation costs. Accordingly, I've provided for such increases in costs in the overall plan shown in the exhibit.

My suggested reduction goals are aimed at variable costs—those costs which represent the same values in every unit we turn out. These goals I've expressed in terms of "cost per truck."

Gets Set to Shrink Costs

President: Thank you for presenting your exhibit. Let's take it as our guide and talk about what we can do to achieve these cost-per-truck reductions. First and fastest area for cost reduction is direct materials, which are the responsibility of Purchasing.

Purchasing Agent: I see that you want to cut the price we pay the engine supplier from $210 to $189 each, and the price we pay the transmission vendor from $98 to $88 each; and that you want to cut costs of other purchased parts and raw materials.

I want to warn you that many of our vendors are facing the same problems of reduced output that Atlantic City Motor Truck Company is experiencing. It isn't going to be easy to get them to reduce their prices to us.

There are a couple of things we could do to help the situation, though. For one thing, Design Engineering and Production Scheduling should be more realistic in the lead times they allow for purchased parts. You fellows never allow enough time.

Then, too, you could be more lenient on the changes that vendors request in order to reduce costs. Let's give these suppliers a little encouragement when they suggest a way to save themselves and us money.

Controller: (to purchasing agent) Maybe you could get better prices from vendors other than the ones we've been using.

Purchasing Agent: Well, I'll certainly give it a try. And I am going to do some bargaining with the vendors we've been using. Maybe I can present our case and shave off a little something here and there.

Factory Manager: I can't help feeling that we're buying some parts outside that we could make cheaper in our own shop on machines that are now idle.

Controller: Maybe we could save money by making those parts in our own plant—and maybe not. Don't forget that through mass-production economies, vendors can sell us certain common parts at prices lower than our costs would be on our own otherwise-idle machines. It may pay us to leave our machines idle.

President: This sounds like the kind of problem that can best be settled by a smaller group. I'm going to ask the Factory Manager, the Chief Engineer, the Purchasing Agent, and the Production

1952 and 1953 Results and Estimate for 1954

	1952 Results	1953 Results	Fixed Costs	Variable Costs Per $1000 Sales	1954 Projected
No. of Units Sold	36,000	32,000			18,000
Sales Price per Unit	$ 1,400	$ 1,400			$ 1,400
	000's Omitted				000's Omitted
Sales Volume	$50,400	$44,800	—	$1000	$25,200
Costs:					
Direct Materials:					
Engine	$ 7,560	$ 6,700	—	$ 150	$ 3,800
Transmission	3,550	3,150	—	70	1,760
Other Purchased Parts	10,240	9,250	—	205	5,200
Raw Materials	7,100	6,200	—	140	3,500
Total Materials	$28,450	$25,300	—	$ 565	$14,260
Direct Labor	3,350	2,950	—	66	1,680
Mfg. Overhead	6,600	6,150	$2,000	92	4,320
Total Mfg. Costs	$38,400	$34,400	$2,000	$ 723	$20,260
Engineering Expense	1,260	1,175	500	15	880
Shipping Expense	1,080	900	—	20	500
Selling and Administrative	5,500	5,225	3,000	50	4,260
Total Costs	$46,240	$41,700	$5,500	$ 808	$25,900
Profit or Loss	$ 4,160	$ 3,100			—$ 700

1954 Breakeven Point—Sales per Year $= \dfrac{\$5{,}500{,}000{,}000}{\$1000-\$808} = \$28{,}800{,}000$

Breakeven Analysis for 1954

	Desired Breakeven Goals			
	Fixed Costs	Variable Costs Per $1000 Sales	Short Term Goal	Long Term Goal
No. of Units Sold			18,000	36,000
Sales Price per Unit			$ 1,400	$ 1,300
	000's Omitted		000's Omitted	
Sales Volume		$1,000	$25,200	$46,800
Costs:				
Direct Materials:				
Engine	—	$ 135	$ 3,400	$ 6,800
Transmission	—	63	1,590	3,180
Other Purchased Parts	—	195	4,910	9,820
Raw Materials	—	133	3,350	6,700
Total Materials	—	$ 526	$13,250	$26,500
Direct Labor	—	62	1,560	3,120
Mfg. Overhead	$2,200	80	4,220	6,240
Total Mfg. Costs	$2,200	$ 668	$19,030	$35,860
Engineering Expense	600	15	980	1,360
Shipping Expense	—	18	450	900
Selling and Administrative	3,000	60	4,520	6,040
Total Costs	$5,800	$ 761	$24,980	$44,160
Profit or Loss		$ 239	$ 220	$ 2,640

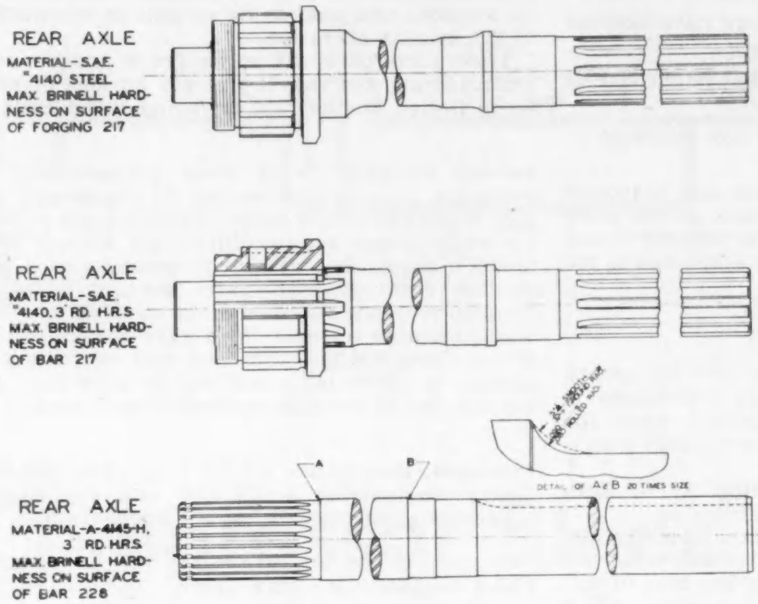
Breakeven Point—Sales per Year $= \dfrac{\$5{,}800{,}000{,}000}{\$1000-\$761} = \$24{,}000{,}000$

Exhibit A

—the Controller's presentation of past figures and the goal

Cost Reduction Goals

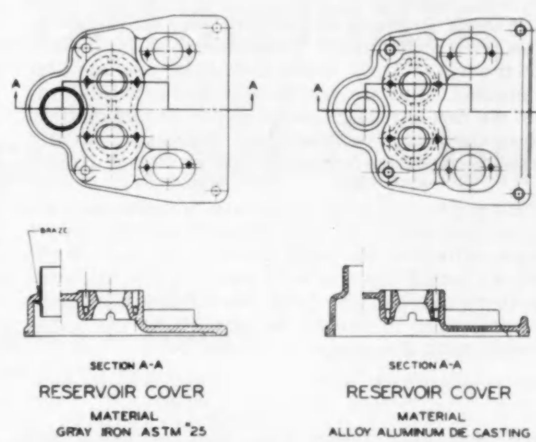
	Present Cost Per Truck	Proposed Cost Per Truck	Reduction Per Truck
Direct Materials			
Engine	$ 210	$189	$21
Transmission	98	88	10
Other Purchased Parts	287	273	14
Raw Materials	196	186	10
Total Materials	$ 791	$736	$55
Direct Labor	93	87	6
Variable Mfg. Overhead	129	112	17
Shipping Expense	28	25	3
Total Program	$1,041	$960	$81



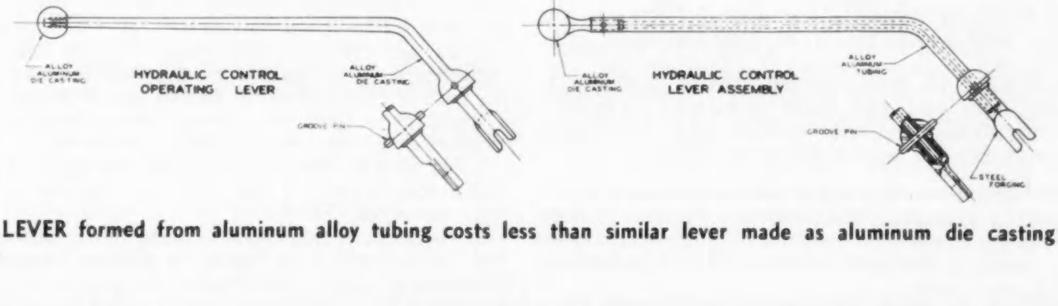
AXLE machined from bar stock is more economical than axle made from forging

Exhibit B

—the Chief Engineer's suggestions on redesign to cut costs



RESERVOIR COVER made as aluminum die casting saves on material and machining and eliminates brazing operation required with cast iron covers



LEVER formed from aluminum alloy tubing costs less than similar lever made as aluminum die casting

Control manager to get together after this meeting breaks up to study the possibilities of:

1. Bargaining with the vendors we have now for price reductions.

2. Calling for competitive bids that might give us lower prices from new vendors.

3. Making some of the parts we now purchase on our own idle machines.

Our chief engineer has had some cost-reduction ideas involving redesign in the back of his mind for some time. This is probably the time we should act on them. For that reason, I've asked him to tell us about his ideas.

Chief Engineer: We've been going over our prints, looking for ways to save money by redesigning to save weight, use less expensive materials, reduce the number of parts to be assembled, or simplify manufacturing techniques.

I've prepared an exhibit (Exhibit B) to show three parts we think we can economize on.

On the rear axle, we think we can save by using bar stock instead of the forging we now use. We propose to machine the part out of two bars of different size. This reduces materials cost, and it doesn't require any major redesign of mating parts.

Also, we recommend lengthening the splines of the axle itself to eliminate use of the steel adapter.

We've tried axles made from bar stock in various of our models. They worked fine in our smaller truck models. But we got fatigue failures at Point B when we ran bar-stock axles in our larger models. Not that the bar stock has less strength. Rather we have changed loads and other operating conditions.

At first we feared that we'd have to increase axle size ½ in. and resort to larger non-standard support bearings—whether we used forgings or bar stock.

Then we found that by cold working the material of bar-stock axles at the fillet, we induced compressive stresses and increased fatigue life to the value obtainable with the larger axle size.

Factory Manager: I like your idea of using bar stock instead of forgings. But I wonder if we really need to stick to alloy steel. How about trying induction-hardened high carbon steel bars instead?

Chief Engineer: That might work. Certainly the carbon steel stock would be cheaper than alloy stock.

We'll make up some rear axles in an appropriate carbon steel and get them induction hardened. Then we'll run them and see how they stand up in service tests. I'll let you know the results.

The other two parts we propose to economize on by making aluminum die castings. We feel that by making the hydraulic control lever a die casting we can produce it for less than our present aluminum tubing lever costs.

Similarly we think that a die cast reservoir cover will be less costly than the present machined cast-iron cover with its brazed-in insert. We can save on material and machining as well as elimination of the brazing operation.

These three parts are only a few of those we are reconsidering, but they'll give you an idea of what we in Design Engineering are doing to cut costs.

Factory Manager: While we're talking about redesigning parts to save money, I'd like to put in a plea for standardizing parts. There are lots of cases currently where a part differs just enough from model to model that we have to retool for each production run. If such parts were standardized through redesign, we could make them on more-or-less automated set-ups. We'd have enough volume to run them steadily. I'm sure that we could save enough on direct labor this way to more than pay for the cost of the new equipment we'd need.

President: Sounds like a good idea. I'm sure that Design Engineering would look into any specific suggestions you have for parts standardization.

Chief Engineer: We sure would. In fact, I'd like to get together with you right away—tomorrow morning, if that's convenient for you—to get your suggestions.

Factory Manager: That's a deal. Maybe before I took a crack at someone else's bailiwick, I should have confessed that there is room for improvement in my own. I realize that we frequently scrap material that we might be able to do something with. I've been thinking that maybe we ought to set up a salvage department which would receive all spoiled materials and parts. The salvage department would then determine whether it is most economic to rework, reuse for another purpose, or sell as scrap or junk.

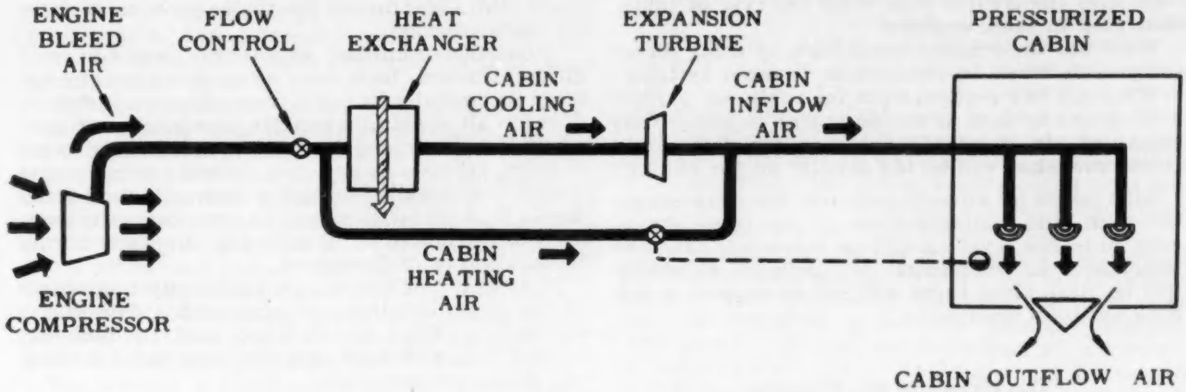
President: That's just the sort of suggestion I had hoped would develop from this little session. I'm not going to pass on it now, or even discuss it. But I am going to ask each of you to look over your own areas and submit a report a week from today outlining what you think ought to be done.

I hope you'll talk over the need for economy with foremen, engineers, accountants, and every other employee who might have ideas on the subject. Enlist their cooperation and listen to their suggestions. We need all the help we can get.

Let's get every management man on our team thinking more about how he is going to accomplish his part in case the work volume is a little higher or a little lower than scheduled. We must make the most of every man and machine, every hour.

I ask you to keep these things in mind, and to make cost-reduction planning your prime task for the next week.

Let's adjourn now until a week from this morning, when we'll meet again to discuss the reports containing your cost-reduction-program suggestions.



Compressor Bleed Air Must Not Contaminate Pressurized Cabins

Lt.-Col. Langdon F. Ayres,
USAF Air Research and Development Command

Report of round table discussion of "The Problems of Compressor Bleed for Cabin Pressurization" held at SAE Summer Meeting, Atlantic City, June 9, 1954.

POSSIBLE contamination of cabin air is today the major problem associated with the use of compressor bleed for cabin pressurization.

The thermal decomposition products of either natural petroleum or synthetic lubricants probably will never be present in sufficient concentration to be a toxicity hazard. But pollution of any kind in the breathing air of crew or passengers is intolerable.

Where cabin air contamination does exist, filters may be a practical solution if the problem cannot be corrected at the source.

It is feasible and practical to use separate fresh air systems, and a small number undoubtedly will be used. However, the direct compressor bleed system has several major advantages, especially for military aircraft. The majority of future systems probably will be direct bleed systems—provided they function satisfactorily.

The advantages of the direct bleed system are great enough to warrant giving the problem of furnishing uncontaminated air careful attention in the design of jet engines, possibly even at some cost in weight. There is considerable optimism that given this attention, the problem of cabin air contamination from the engine lubricating oil can be eliminated.

Cabin pressurization by direct bleed from the compressor of turbine engines is an accepted practice in military aircraft. However, in several recent applications complaints of cabin air contamination have been received. This raises questions:

Is the contamination due to the design features

and operating characteristics of the newer, more powerful engines?

Or does the trouble stem from the type of lubricant used in these engines?

What are the relative advantages of using direct compressor bleed, in comparison to other systems?

What are the requirements for cabin air purity?

What can be done to the jet engine to assure that breathing-air standards are met for compressor bleed, and what will be the penalty on the engine?

High-speed jet aircraft make terrific demands on the pilot, and contamination of the cabin air at even nuisance level cannot be tolerated. Just as important, in commercial jet airliners reliability will be vital, since there will not be oxygen to fall back on in an emergency.

The Nature of the Problems

The compressor of the gas turbine engine is an obvious source of substantial quantities of compressed air. Direct use of this air for cabin pressurization avoids the extra space and weight requirements of a separate cabin supercharger. Compressor bleed has been used successfully for some time in bomber and fighter aircraft, from both turbojet and turboprop engines. Turbosuperchargers in piston engine aircraft likewise have been used successfully for cabin pressurization. The problems are somewhat similar, at least to the extent that the effect of the air extraction on the engine thermodynamic cycle must be considered.

The performance penalty on the engine, of course, depends on the amount of air extracted. In transport aircraft about 1 lb of air per min for each passenger is needed. In fighter aircraft the requirement may be as high as 7 lb per min. In actual usage the extraction for cabin pressurization generally runs about 0.5% of jet engine airflow at 35,000 ft altitude, increasing to perhaps near 1% at 65,000 ft. In jet engine performance, extraction of 1% of the air at Mach 0.9 at 35,000 ft or higher results in a loss of net thrust at normal continuous rating of 2.6%, and an increase in specific fuel consumption of 1.9%.

In an average turboprop engine, bleeding 1% of the air from the compressor might result in a power loss of perhaps 2.7%, accompanied by an increase in specific fuel consumption of 1.7%. However, for a given airflow requirement, the percentage of bleed required from the turboprop is likely to be two or three times higher than from the turbojet. The reason for this is that the turboprop (within its range of application) has a smaller compressor than a turbojet engine of equal thrust. On the other hand, the turboprop probably will have the highest pressure ratio available.

The possibility sometimes exists of extracting cabin air from a lower stage. Each case should be examined individually in the light of engine overall pressure ratio, operating altitude, and required cabin pressure.

The extraction of engine cycle air from the turbosupercharger of piston engine aircraft will be very much larger in comparison to the gas turbine engines. However, under many operating conditions an excess of power will be available to the supercharger turbine.

The airplane designer regards the loss of engine performance due to air bleed for cabin pressurization as practically inconsequential. From the airplane man's standpoint the major problem is cabin air contamination.

Thousands of military airplanes of over a score of different models have been using direct compressor bleed successfully for cabin pressurization. Instances of cabin air contamination are infrequent and generally can be traced to specific causes. On older engines, accessories and fuel controls were located where leaks resulted in fuel or hydraulic fluid being drawn into the compressor. In some cases the trouble was attributed to oil spilled in the ducts during installation or maintenance.

In several new aircraft an apparently new source of air contamination has appeared. This is the engine lubricating oil. In most cases, the difficulty is associated with high-pressure-ratio engines which use synthetic lubricants.

In some airplanes, contamination has been manifested from the beginning of flight testing and has continued unabated for over 60 flights. **The effect of engine-lubricating-oil contamination on pilots has been eye irritation and headache.** The intensity of contamination has ranged from objectionable odor to visible smoke. In one airplane the fumes were most severe at high indicated airspeeds below 10,000 ft altitude. In another airplane the periods of heavy contamination were reported to be concurrent with change from low power to high power in flight.

In all cases where contamination has appeared, it has been the practice for the crew to breathe 100% oxygen while the cabin pressurization system is operating. Analysis indicated that the smoke and fumes are a mixture of the products of the thermal decomposition of engine lubricating oil.

While the reports of contamination from the airplane manufacturers follow a fairly consistent pattern on particular aircraft, reports originating within the military services are assuming a more random pattern. The effects of the bad air are alleged to extend to dizziness and nausea. All cases are being investigated as carefully and thoroughly as possible. Since the fact that a contamination problem exists on some new aircraft is widely known, the possibility of suggestive psychology is not being overlooked.

The Human Factor

The possible detrimental effects of air contamination on the pilot and crew are hazards to health and impairment of operating efficiency. The first is a problem in toxicology; the second would normally be referred to in industry as air pollution. No materials can be tolerated in the breathing air of human beings who are responsible for the operation of complex, hazardous, and costly equipment which would interfere in any way with efficiency of operation and performance.

There is a need for better instrumentation for detecting and measuring contamination. Man's nose will detect 0.005 parts per million, subject to some variation from one individual to another. Current instruments can detect contamination only when it reaches the order of 2 or 3 parts per million.

Interest in the toxicology of synthetic lubricating oils for jet engines has prompted a rather extensive study of commercially available and approved en-

gine oil and several of the chemical materials that may be used as bases for lubricating oils. These include ester derivatives of sebacic acid, adipic acid, azelaic acid, and pelargonic acid. The practical hazards to humans from these compounds were found to be almost nil.

The thermal decomposition of these ester derivatives increases their toxicity considerably. It has been demonstrated that this toxicity was due primarily to the ester base which is the principal ingredient in many formulations. There is a critical temperature above which toxic compounds begin to form. This is between 400 and 700 F, depending on the starting compound. At temperatures higher than the critical temperature, the rate of decomposition is faster and the resulting fog more dense, but the nature of the decomposition products appears unchanged up to 900 F.

The toxicity of the thermal decomposition products of these esters is not peculiar to this class of chemical compounds. Similar effects on animals were obtained with the thermal decomposition products of a typical paraffinic hydrocarbon oil. It is probable that the pyrolysis products of aliphatic hydrocarbons should be similar qualitatively and perhaps differ quantitatively. (However, some investigators disagree with this contention.)

While the thermal decomposition products of lubricants are potentially toxic, high concentrations of these materials have not been found in the cabin air, and health hazards to crew members are not anticipated. However, health hazards need not be demonstrated to establish the need for air pollution correction. Even the minimum effects—eye and nasal irritation—are intolerable.

Besides, smoke caused by conditions other than fire may result in confusion, obscuring true fire hazards. In at least one instance the smoke became dense enough to interfere with instrument visibility. Also, the substances that constitute the smoke, and the corrosive nature of the fumes may be detrimental to sensitive instruments and to material such as rubber, plastics, and paint.

What Can Be Done To The Engine

The modern trend to side mounting of engine accessories rather than nose mounting removes fluid lines from the compressor inlet area. This practically eliminates the hazard of bleed air being contaminated due to fuel or hydraulic leaks around engine controls and accessories.

Cases have been encountered where backflow in the diffuser between the compressor and combustor carried fuel from leaking nozzles back to the bleed ports, resulting in polluted air. An improved o-ring seal arrangement corrected this trouble.

The use of synthetic lubricants in the newer gas turbine engines is highly advantageous and in many cases is necessary for satisfactory operation. The wide temperature range where satisfactory operation is possible, and the higher load-carrying ability of the synthetic oils, are properties which the engine manufacturers and the military services will demand. It appears then, that if bleed air contamination is to be avoided, attention must be given the problem in the basic design of the engine.

The arrangement of bearing seals and air extraction ports is probably the most important of the features requiring careful analysis during design. The scheme of using two oil seals with a cavity between them, pressurized from a source of air where the pressure is higher than on the bearing side of the seal, is more or less standard practice. This problem of sealing should receive continued attention during development, since it has been observed that **the effect of shock waves in the labyrinths, and pressure variations during transients, may result in situations where the pressure-differential seals will not be effective.** These conditions many times cannot be predicted from rational analysis.

The demand for lighter engines has lead to the use of rubbing seals which some engineers believe are not entirely reliable. Rubbing velocities used are from 200 to 300 ft per sec. Two-spool engines offer another chance for oil leakage at the intermediate bearing seal. Rubbing seals used with labyrinth seals having a pressurized cavity between is a possible solution. The differential pressures across the seals must be carefully examined during development testing of the engines, because unexpected phenomena can occur. Figs. 1–4 illustrate some typical bearing and seal arrangements.

It is logical to believe that extraction ports located around the inner annulus of the air passage will minimize air contamination. The rotation of the compressor will tend to centrifuge droplets and solid particles to the outer surface of the annulus. The experience on engines incorporating center bleed has been good.

Other Possible Solutions of the Problem

Filtering the air going to the cabin may be one possible solution when air contamination does exist. Filtering can remove solid particles, liquids, and gases.

Each type of filter has special characteristics. The particulate filter removes discreet particles suspended in air and is good up to about 1000 F. The absorptive type—for example, activated charcoal—will remove vapor contaminants but is good only up to about 100 F. The condensation filter removes vapors by condensation. The catalytic filter oxidizes vapor contaminants to harmless products, usually carbon dioxide and water. It has the disadvantage of requiring high temperature, above 300 to 400 F. The liquid scrubber type filter removes discreet particles by washing and absorbs vapors. (See Tables 1 and 2.)

The location of the filter in the system will depend on a number of factors. The temperature at which the filter is most effective will, for example, influence its location with respect to heat exchangers and refrigerating work turbines.

A lot of development and testing is required to adapt even available filter materials and types to a satisfactory aircraft system. And, naturally, filters are not a desirable solution from the aircraft manufacturer's viewpoint.

Separate cabin superchargers, sometimes referred to as fresh air systems, also are a solution to the problem of providing pressurizing air to the cabin. With a few exceptions, all pressurized commercial airliners now operating use such a system. These separate superchargers are being used at comparatively low altitudes, whereas jet transports would probably operate at a much higher altitude, requiring a high pressure ratio supercharger.

Fresh air systems have their own problems, of course. Staying within the surge limits of the cabin supercharger is a problem with the wide range of pressure ratios and airflows required. The whole system is more complex, especially in the controls, where there is a major order of difference. A direct bleed system is estimated to take up only about one-half the weight and volume of a separate system. Fig. 5 illustrates the relative complexity of the direct and the separate air systems.

The relative merits of the separate air system may be set down as:

Advantages

There is no contamination of cabin air by engine lubricants.

Cabin conditions are not so dependent on engine power settings.

On some airplanes, specific fuel consumption may be reduced.

Disadvantages

The separate air system is larger and heavier.

It is more complex.

It costs more and is harder to maintain.

On aircraft where the separate cabin supercharger is driven by a bleed air turbine, the performance penalty on the aircraft may be higher than with direct bleed, especially if the required cabin air pressure approaches the maximum available from the turbojet compressor.

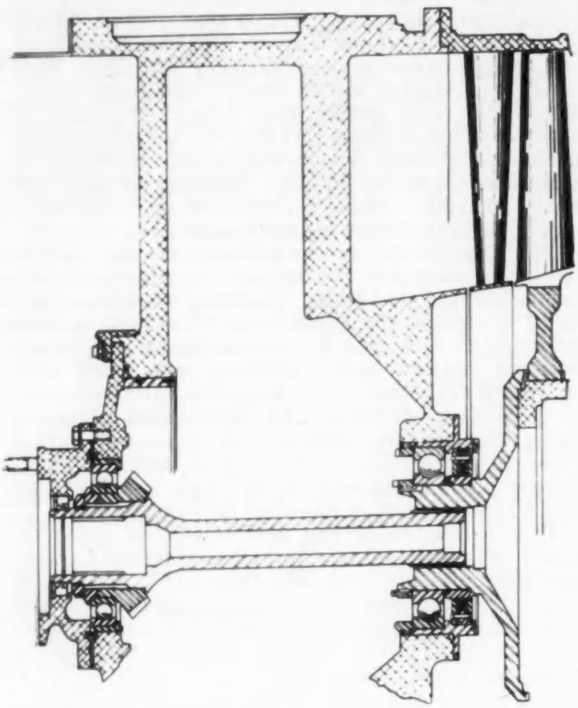


Fig. 1—Contact-type oil seal without pressure balance located at compressor inlet end bearing

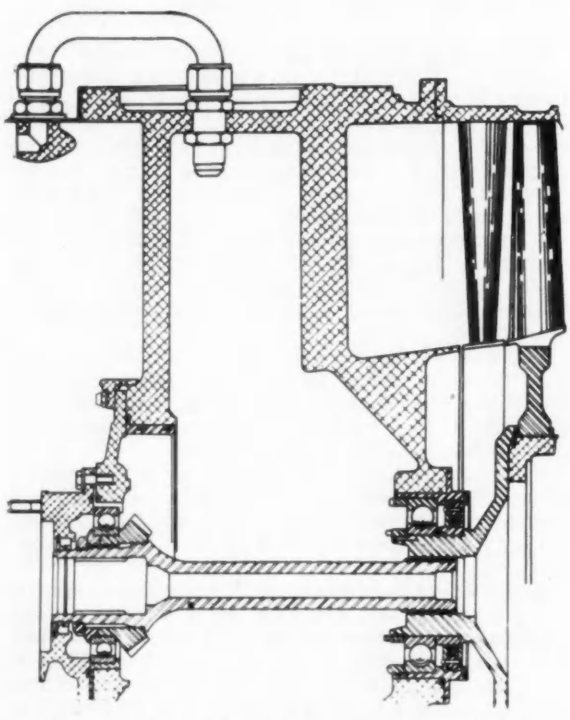


Fig. 2—Face contact-type oil seal at compressor inlet end with pressure balance across seal

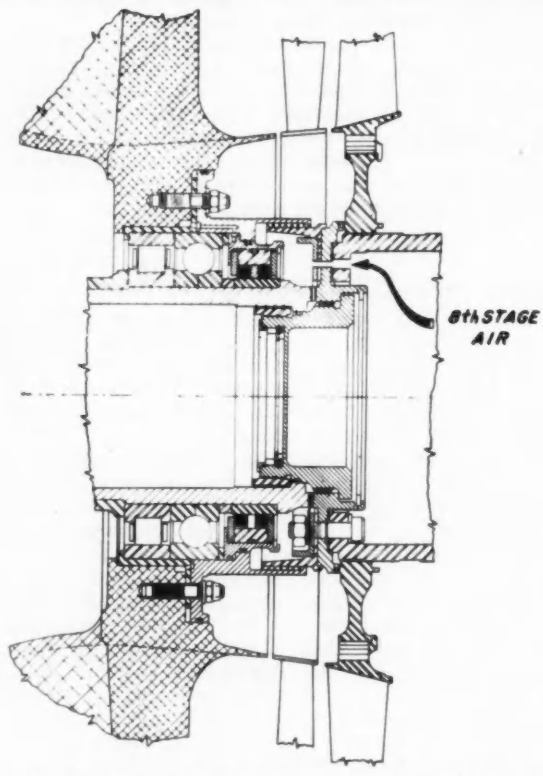


Fig. 3—Large-size face contact-type seal for turboprop with constant pressure difference across seal

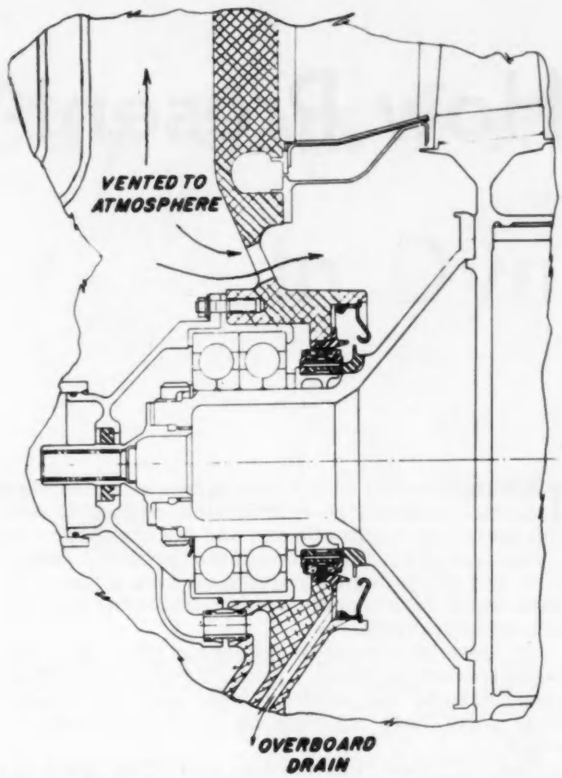


Fig. 4—Face contact-type oil seal with vent to atmosphere on both faces and scupper for drain of static leakage

Table 1—Filter Locations

	POSSIBLE FILTER LOCATIONS					
	UPSTREAM		MIDSTREAM		DOWNSTREAM	
CONDITIONS	Min.	Max.	Min.	Max.	Min.	Max.
Pressure, psia	15	150	15	150	10	15
Temperature, F	100	600	0	200	- 100	300
Flow, cfm	0	100	0	75	0	300
FILTER TYPE						
Particulate	possible		possible		possible above 32 F	
Adsorptive	impossible		OK only at lower temperatures		possible	
Condensation	impossible		impossible		possible	
Catalytic	possible		possible at high temperature only		impossible	
Liquid Scrubber	impossible		possible		possible	

Table 2—Filter Types

FILTER TYPE	TYPICAL MATERIAL OR METHOD	FUNCTION	TEMPERATURE RANGE
Particulate	paper or electrostatic precipitator	removes descrete particles suspended in air	up to 1000 F with certain paper mat'ls
Adsorptive	activated carbon	removes vapor contaminates by adsorption	up to approx. 100 F - desorbs at high temps.
Condensation	low temperature heat exchange	removes vapors by condensation	depends on volatility of contaminate
Catalytic	metal oxides	oxidizes vapor contaminate	requires high temperature to function
Liquid Scrubber	water	removes discrete particles by washing and adsorbs vapors	depends on liquid used as scrubbing agent

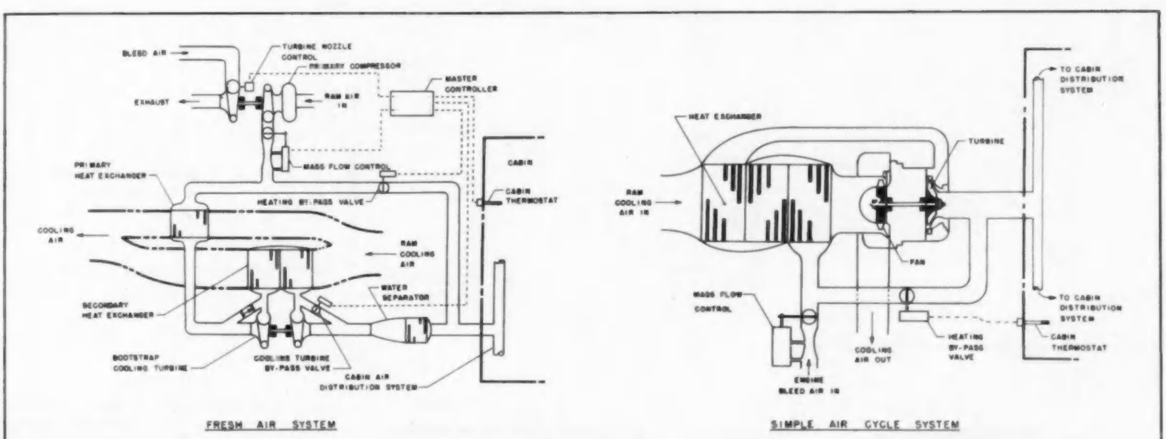


Fig. 5—Fresh air system at left is considerably more complicated than simple air cycle system at right

PRESENTED here is part of a paper on some of the effects of tires on car stability. The complete paper also discusses the relationship of the driver to stability measurements and an investigation of the transient behavior of tires. In addition, it contains equations that describe the rate at which the cornering force of the tire changes with the slip angle and the lateral motion of the rim on the road.

Some Definitions

AN understanding of the accompanying article on how tires perform in dynamic steering requires a knowledge of what several terms used in tire engineering circles mean. These terms and their definitions are:

Slip Angle—Angle between the plane of the tire and the direction of travel along the road.

Cornering Force—The corresponding side thrust.

Cornering Power—Ratio of cornering force to slip angle.

Reduced Cornering Power—Ratio of part of cornering force that results from internal stresses of the tire to the slip angle.

Adjustment Rate Constant—Proportional to rate of adjustment of the tire, when steered to a slip angle.

Reciprocal of Adjustment Rate Constant—Length of travel in which a unit measure of adjustment takes place.

How Present-

TIRE stability—or how a tire causes an automobile to react to steering—is intimately related to both the operating conditions and the design of the tire.

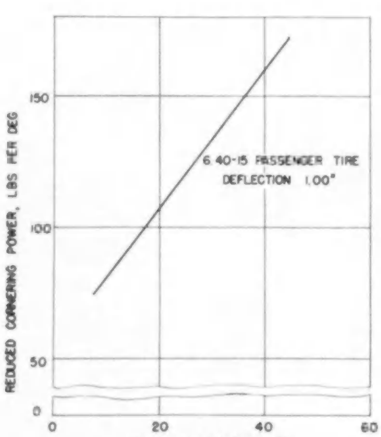
Figs. 1–5 show how tire inflation pressure, deflection, and size influence reduced cornering force and adjustment rate constant—two parameters that are related to stability.

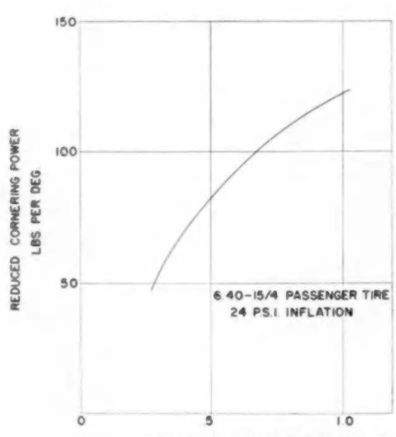
The rate of change of cornering force with distance traveled is directly proportional to the difference between the existing force and the steady-state force that corresponds to the existing slip angle.

Figs. 1–3 show that reduced cornering power increases as inflation pressure, section diameter, and deflection increase.

It should be noted that the load on the tire has no direct effect of its own. There is, however, an indirect influence on reduced cornering power, since the load and inflation together act to determine the amount of the deflection.

The reduced cornering power rises steadily with





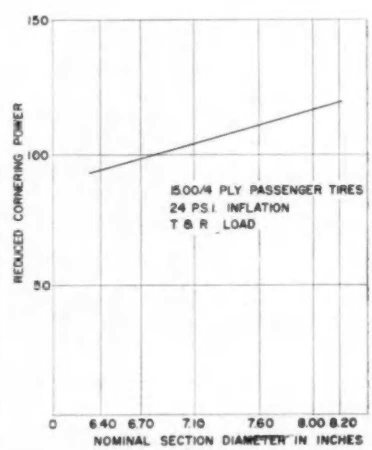


Fig. 1 (left)—Reduced cornering power versus inflation pressure. Fig. 2 (center)—Reduced cornering power versus deflection. Fig. 3 (right)—Reduced cornering power versus tire size

Day Cars Perform In Dynamic Steering

S. A. Lippmann, United States Rubber Co.

Based on paper, "Car Stability and Transient Tire Forces," presented at the SAE National Passenger-Car, Body, and Materials Meeting, Detroit, March 4, 1954.

increases in cross-section (as shown in Fig. 3) if the various sizes are operated at the conditions recommended by the Tire & Rim Association. Let us consider the effect of size in another way. The ratio of the mass of the car to the cornering power is an index of the ability of various sizes of tires to steer the vehicle. According to Fig. 3, this ratio increases slightly with the weight of the car, provided the recommended operating conditions are adhered to. (This is true because heavier cars use tires of larger cross-section.)

Figs. 4 and 5 show that the reciprocal of the adjustment rate increases with both tire deflection and tire size. Unlike the cornering power, this quantity is usually insensitive to the inflation.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

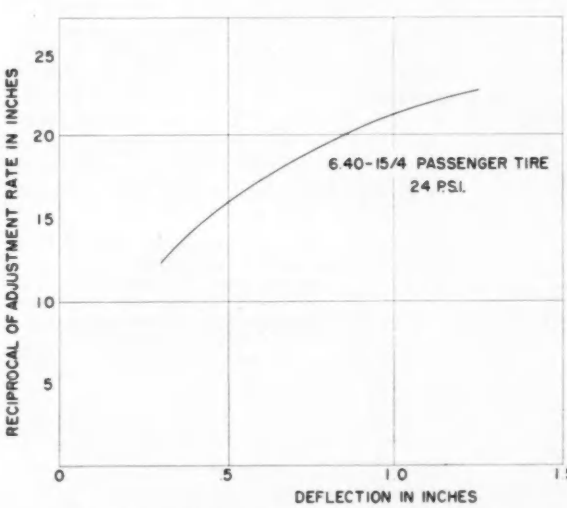


Fig. 4—Reciprocal of adjustment rate versus deflection

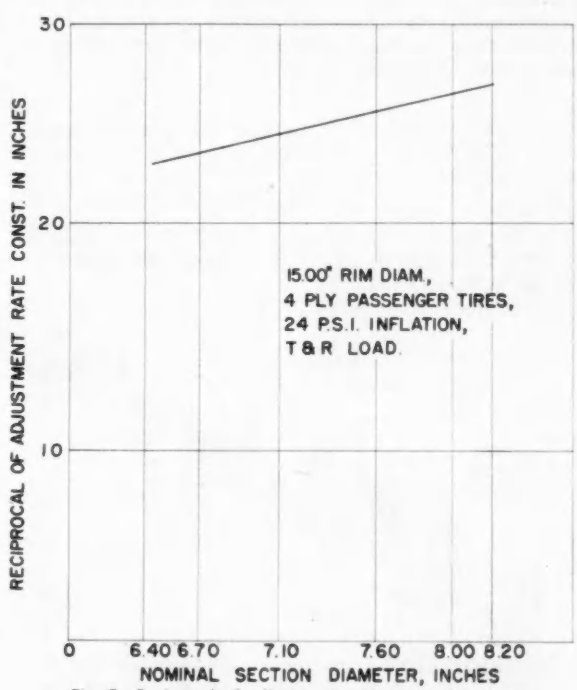


Fig. 5—Reciprocal of adjustment rate versus tire size

Automation

How to Apply It

THERE is a place for automation in most manufacturing plants, large or small. The extent to which it can be applied economically is determined by the volume and nature of products manufactured, not by the size of the business. Generally speaking, in low production volume with special machines, it is best to load and unload with unskilled help. But there are often high volume items in job shop operations which lend themselves to automatic operation.

Automation, which may be defined as continuous automatic production, seems best achieved through progressive steps. An automation program can be established which aims at upgrading each operation one or two steps at a time—such as hand operations into the mechanized area and the mechanized operations into the area of automation. See Fig. 1.

It is unnecessary to automate an entire section or department. You can start with a few machines

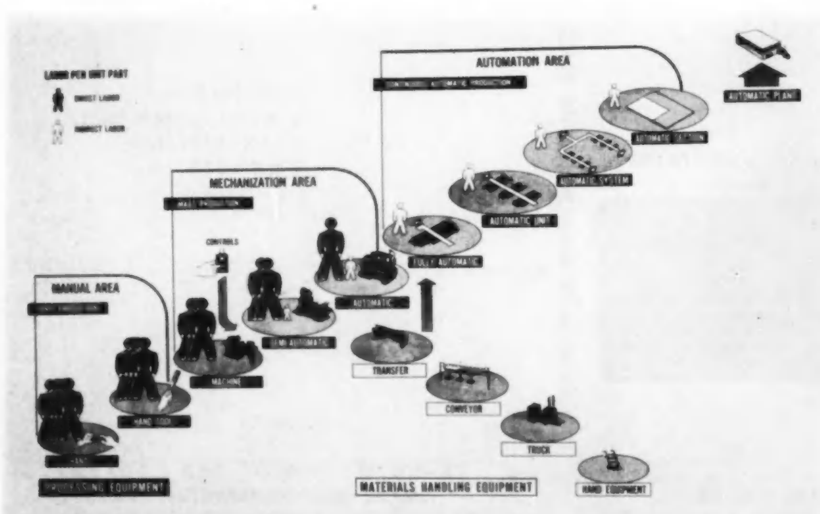


Fig. 1 — Automation can and should be approached by upgrading each operation. Here are shown the progressive steps to automation in the metalworking industry

and Make It Work

R. A. Igras, Ford Motor Co

Based on secretary's report of panel on Automation—Manufacturing Research held as part of the SAE Chicago Production Forum, March 29, 1954.

and progress to other operations as experience is accumulated.

Automation eliminates unskilled help while demanding personnel with added skills. How much this influences cost is problematical. In one instance, a 50% theoretical cost saving through automation dropped to 33% with actual maintained production.

Industries getting into automation are plastics, television, electric motors, paper, oil wells, and food processing. The automotive industry is beginning to put automation to work in its plants. Most dramatic has been its application to cylinder block machining. In forge operations, automation has been applied successfully to:

a. Automatic compound bending of heated bars from furnaces, through oil quench to draw furnaces.

b. Automobile coil spring manufacture from raw stock.

c. Automobile leaf spring production.

1. Equipping Existing Machines with Automation

Most general purpose machines are inherently low production by cycle time and design, but many can be used as high production tools when properly fixtured. The first step in automating them is to see if they can be loaded and unloaded automatically. This will eliminate a number of them immediately.

Manpower savings, production per hour, and nature of the product should be balanced against the cost of automation equipment. The production life of the part produced is another factor for consideration and one that regulates amortization and automation depreciation.

"In-line processing" is an important item when considering the automatic transfer of parts between manufacturing operations. With "departmental

processing" application of automation transfer equipment is extremely limited. This suggests the importance of plant layout.

In general, the following machines lend themselves to automation loading and unloading:

- Automatic screw machines
- Automatic milling machines
- Drill presses
- Wet belt sanders
- Punch presses
- Centerless grinders
- Gardner through-feed face grinders
- Heald I.D. grinders

Among special automatic machines suitable for automation may be mentioned:

- Index (dial) table processing machines
- Tracer lathes
- In-line transfer type machines
- Dieing machines

Assembly machines afford the major field for automation application in the future. It is seldom possible for a machine to assemble anything completely without human aid. The limitation lies in the economics ruling expenditure for machines, not in the machines themselves. The most popular form of the assembly machine is the Index (dial) table machine.

2. Power and Free Assembly

The basic principles of assembly demand continuous mechanical pacing to eliminate bottlenecks, minimize banks, and facilitate pinpoint scheduling while retaining unlimited flexibility in control.

These basic principles must be satisfied and attention focused on automatic dispatching and sensing to adjacent specialized work places. In short, many assembly automation problems can be solved if the part can be shunted to a particular station automatically, and located without disrupting the basic principle of assembly line operation.

The "power and free system" appears to be the most successful solution to date to the demands for automatic assembly. The part is attached to a carrier suspended from a free trolley traveling on an overhead rail. Directly above the load rail is a standard overhead power-driven trolley conveyor with pusher dogs attached at regular intervals. The load carrier is pushed by the trolley conveyor rather than carried by same, since the carrier has its own load rail.

Automatic switches shunt the loads to adjacent stations for specialized automation operations. The assembly line is kept full because the space resulting from a carrier switching out to an operation is filled by a carrier which has been processed and is waiting to be fed back automatically into the assembly line. It is possible to have emergency accumulation before and after an operation, thereby dampening the routine breakdowns in a particular work center.

Power and free conveyor systems have been used for many applications, ranging from small instruments to parts as large as automobile bodies and corn pickers.

3. Tool Scheduling

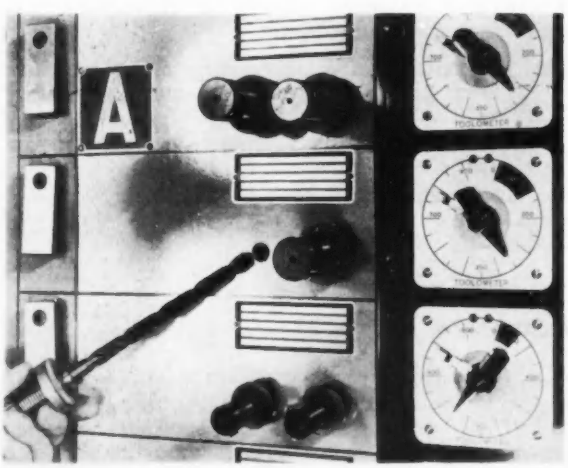


Fig. 2—Tool operations can be programmed with a toolometer. It counts the number of tool operations and shuts down the machine when the schedule is completed. The time for tool change is predetermined, not guessed at by the operator

In theory, transfer machines offer limitless possibilities for combining operations; in practice, there is a very definite limit. It is the downtime for changing tools.

Consider a multiple station machine having 120 tools that need changing every 4 hr. If it takes 2 min to change a tool, the total time for changing is 4 hr, so the machine will produce for 4 hr then be down for four hours. Downtime increases in some proportion to the number of tools in the machine.

One solution to this problem is automatic tool programming for each individual tool, which means to schedule tool operations from the time the tool is put to work until it is removed for resharpening.

Most tool programming is now under operator control. He keeps a mental note of its progress and removes it when he thinks it dull. In larger machines, programming is non-existent—the tools are put to work and forgotten until they are broken from over-use.

Tools were once under close observation in single station machines; now, in transfer machines, they

are far removed from personal attention. This is why some flexible programming device is essential.

Scheduling tool operations can be programmed with a toolometer, a device which counts the number of tool operations and shuts down the machine when the schedule is completed. It's shown in Fig. 2. Accompanying this is a machine control unit comprising two complete sets of pre-set tools for the entire machine so that change can be made without loss of downtime, or within specified limits. See Fig. 3.

This is how the system works. An analysis is made of the time required per shift to change each tool. Operations are then grouped and the line is divided into sections depending on the position of the part and the total time required per shift to change the tools in each section. The section requiring the greatest downtime will determine the line downtime. In operation, the operator inserts the parts in station 1 of section 1 and initiates each cycle. From there on the parts are handled automatically. Toolometers keep the count and when it is time to change tools in section 2, for example, toolometers shut down this section, but all other sections keep operating.

Parts coming out of section 1 are banked up in front of section 2, and parts previously banked ahead of section 3 are fed into the line at this point. After tool change and resetting of toolometers, section 2 returns to automatic operation in sequence with the line. By shutting down only one section at a time, downtime does not accumulate.

Several approaches have been made to the problem of cutting downtime. Highly successful has been the application of the recording tool board. This, together with banking and debanking facilities of automatic type, could bring line efficiency to 97%. It is thought generally that the size of banks is not altered by automation.

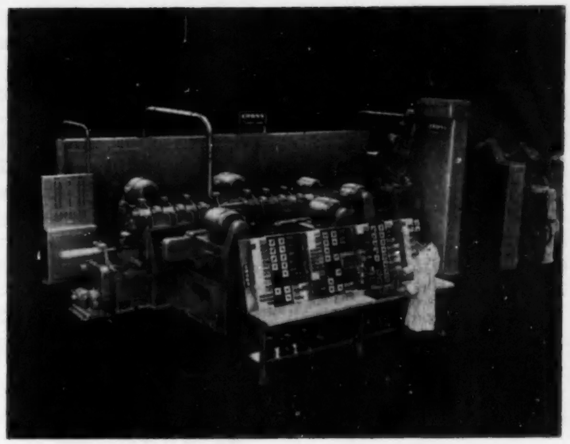


Fig. 3—This machine control unit, comprising toolometers and sets of pre-set tools, controls sections in the line so that they are shut down independently for tool change while the rest of the line keeps going. Accumulation of downtime is prevented

In some operations, such as pressed steel, floats are required to cycle operations and so make use of the available capacity of equipment. There are two schools of thought regarding continuous operations such as engine production. One school advocates substantial floats between in-process operations of a size to insure against lost production due to tool changes and unpredictable breakdowns. The other school does not advise in-process floats. Time for tool changing and break down is obtained by using only 80% of rated capacity of equipment to obtain required production, which is normal procedure today.

4. Developing an Automation System

The automation designer and his supervisor are at the center of an automation program development.

One of the automation designer's first duties is the preparation of a plant layout. The first stage is a preliminary one to serve as a guide in developing the final plan. The automation engineer becomes active in the preliminary stages and normally should concentrate on handling a complete part so that he will understand the overall requirements of the job.

In some cases, it is found that the right type of automation equipment will cost little more than standard conveying devices which would be required as a minimum. Close coordination is needed to get the best out of expenditure for conveying devices.

At the completion of preliminary studies, it should be possible to make a sufficiently detailed automation layout to permit the automation engineer to prepare final recommendations. When the overall study is completed, the equipment specified should be analyzed to determine the estimated cost of the various units. At this stage, the industrial engineering department should be called in to analyze manpower requirements for the entire layout, both with and without automation, to show the variance in labor requirements. When the work is completed, the following data will be available:

1. Estimated cost of the equipment.
2. Savings in handling labor and other benefits.
3. Preliminary automation layout.
4. Sufficient detail to be certain of practicability of special features.
5. Scale models of perspective drawings as required.

Upon approval of the program, the automation

department should take immediate steps to assure the coordination which is needed for success of the program.

Very often compromises must be made with the ideal system in a new installation to keep production going or to keep costs at reasonable level. It is important that all the factors peculiar to this type of arrangement and improvement program be brought out during preparation of the preliminary automation program. Planning for automation should start from 18 months to two years prior to the scheduled production date of the plant.

Design standardization is highly important and should be considered in all planning. Here are the main points:

Machinery should be located to allow development of a standard length section of automation which can be produced in multiples, depending upon the arrangement required. This will help fabrication and keep costs down.

Uniform elevations at loading and unloading end of machines will simplify installation and replacement.

Use of a standard automation drive unit is recommended. It can be used any place throughout a system and will make possible reduction in number of spare parts, and help reduce operational overhead costs.

Design standardization should be supplemented by JIC and existing company standards. One concern traced excessive maintenance costs of earlier installations to lack of standards. Standards call for better identification of control circuits, greater accessibility of components, and better protection from contamination.

5. Future of Automation

Continuous research goes on in the field of application. One concern is working on automation power units. In a fully automated area, the amount of air exhausted by power units is considerable. It can become a costly item if preventive maintenance is not practiced to the utmost.

Sound preventive maintenance programs are also in the making. In an area where in-line machines are interlocked with full automation, breakdowns are invariably blamed on the automation. To investigate and overcome this, one company purchased a multi-channel recorder. The instrument, when tied into strategic circuit locations of machines and automation in troublesome areas, will record the functions of each machine station or automation cycle. From these data it is hoped to determine the source of many troubles and to take corrective measures from a design standpoint. These data will also provide a basis for determining projected life of components. That will permit setting up a realistic preventive maintenance program.

The future of automation will be assured and the automatic factory will be well on its way if:

1. Top management gives it continued interest and support in the light of benefits to be gained.
2. Industry continues to develop machine tools, material handling, process equipment, taking into account full significance of automation.
3. Closer coordination develops between the user and manufacturer of machine tools and equipment.
4. Closer cooperation develops between the many designers and builders of machine tools and equipment.
5. Information on the subject is circulated to groups in organizations and technical groups not now actively working on automation as a definite program.
6. Additional sources are developed for the design, building, and installation of automation.

(The report on which this article is based is available in full in multilithographed form together with reports of seven other panel sessions of the Chicago Production Forum. This publication, SP-306, is available from the SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.)

The panel of automation experts who led the discussion highlighted in this article were:

Panel Leader:

William R. Slattery,
Ford Motor Co.

Panel Secretary:

R. A. Igras,
Ford Motor Co.

Panel Members:

P. H. Alspach,
General Electric Co.

R. E. Cross,
The Cross Co.

J. B. Cunningham,
Wilson Automation Co.

S. M. Kavieff,
Jervis B. Webb Co.

J. McDougall,
Ford Motor Co.

Self-Shifting Transmissions for Trucks

They're On the Way

D. T. Sicklesteel,
General Manager, Products Development Laboratory, Borg-Warner Corp.

Excerpts from paper "Possibilities of Planetary Gearing for Full Torque Shifting Transmission for Commercial Vehicles," presented at SAE Summer Meeting, Atlantic City, June 8, 1954.

THE long-recognized need for full torque shifting transmissions in the commercial field is starting to be met. But the many different requirements of the field make the transition from mechanical to automatic drives a much more cautious evolution than in the passenger car field. The problem also presents so many cost, weight, and size limitations. These together with conflicting requirements for performance, feasibility, and efficiency make it an extremely difficult job.

A major part of the commercial field is long-haul highway trucks. The highway haulers use long-life engines governed to safe speeds, and desperately need to keep the engine speed near governed top to assure maximum performance and efficiency. The sliding gear transmissions with auxiliary transmissions and two-speed axles in some present designs now use 10 to 12 successive gear steps of approximately 1.3 ratio to cover an overall reduction of 13.6 to 1. They now provide highly efficient drive ratios for every gradient encountered on all principal highway routes.

Any new transmission introduced has a difficult job to equal or exceed the performance of the present sliding gear multiple transmissions used in the highway haulers. Economy is as important as performance. That's because the biggest single expense in the long-distance truck operation is the fuel bill.

There are, however, some irritating shortcomings in the present transmissions that offer a chance for new designs to score valuable points. Due to the great number of gear steps required, it is very difficult to always keep the sliding gear system in its ideal drive ratio. Such operations require experienced and conscientious drivers. Performance and economy losses shifting gears in present transmissions vary with the driver's expertness. His task is not simple on long-haul commercial highways, where numerous grades and impeding traffic conditions are met. An automatic transmission would find a ready market if it would: (1) guarantee correct drive ratio under all conditions, (2) operate equally well with all kinds of drivers, and (3) improve truck fleets' average performance, if not also the average efficiency.

Pickup and delivery trucks in metropolitan areas present a less difficult problem. Their transmission problem is similar to the light-weight city service bus problem. Long life with good reliability, automatic ratio changing providing acceleration to traffic speeds, and fairly high efficiency are prime requirements. Weight and size are important; but cost has to be kept down since this type vehicle is generally low priced.

The military field presents its own problems and needs. Mechanical reliability, performance, ease of operation, maneuverability, efficiency, minimum maintenance, compactness, minimum weight and cost are all universally admitted virtues in military transmissions. Where maximum gradeability would

often be required unexpectedly, and maximum acceleration to top speed after a momentary slowdown was of prime importance, the gear shift transmission proved unsatisfactory. The extreme demands of maximum tractive effort with high top speed required a very high spread of transmission ratio, easily available to the driver. These requirements apply somewhat to heavy-duty, off-the-road vehicles, as well as to the Army's cross-country track laying and wheeled vehicles.

During 1953, over 50% of American passenger cars were produced with automatic transmission. These various transmissions all used planetary gearing for automatic shifting, together with fluid drive of the fluid coupling or torque converter type.

Some of these transmissions are now being used in commercial vehicles very successfully. They are being "beefed up" for still more commercial applications.

The HydraMatic transmission has been available for several years in light delivery trucks and small city buses. It is now offered in current production in conjunction with a synchornized manually-shifted countershaft type auxiliary unit for 2½-ton General Motors trucks. This is a two-range unit giving four automatic speeds in the low range, and four automatic speeds in high range. The two-speed axle is not being offered with this transmission.

Also in current production in the M-135, 2½-ton 6×6 military truck is an expanded HydraMatic transmission with eight speeds forward and two in reverse. This is accomplished through the use of an auxiliary two-speed planetary gear set built integral with the main transmission. The truck has a maximum speed of 58 mph carrying a 10,000-lb load. The transmission operates through two gear ranges, a high and low. This combination relieves the driver of all discretion relative to gear selection, except for shifting between high and low ranges.

Another late development is the GMC Twin HydraMatic drive for heavy-duty trucks. See Fig. 1. This drive combines automatic shifting with sufficient gear ratios to meet heavy-duty hauling requirements.

It consists of two HydraMatic units mounted one above the other. This combination provides seven closely spaced forward gear ratios and one reverse. A three-speed auxiliary gear box mounted behind the automatic drive provides three driving ranges at the option of the driver. Theoretically there are 21 different gear ratios. But due to certain overlapping ratios in each range, 13 gear ratios and three reverses are available.

The input is through a fluid coupling. The turbine member of the coupling is fastened to a planetary gear set, which acts as a differential and operates both upper and lower HydraMatics. They are governed to shift independently and alternatively with each other. Both units drive through a single output shaft.

Gear ratios in the seven-speed HydraMatic and three-speed auxiliary are:

Seven-Speed HydraMatic	
1st	2.90
2nd	2.34
3rd	1.86
4th	1.45
5th	1.10
6th	0.89
7th	0.71
Reverse	3.21
Three-Speed Auxiliary	
Direct	1.00
Low	2.00
Creeper	3.87

Starting in "creeper" range, the automatic will shift through to its seventh gear, then will shift

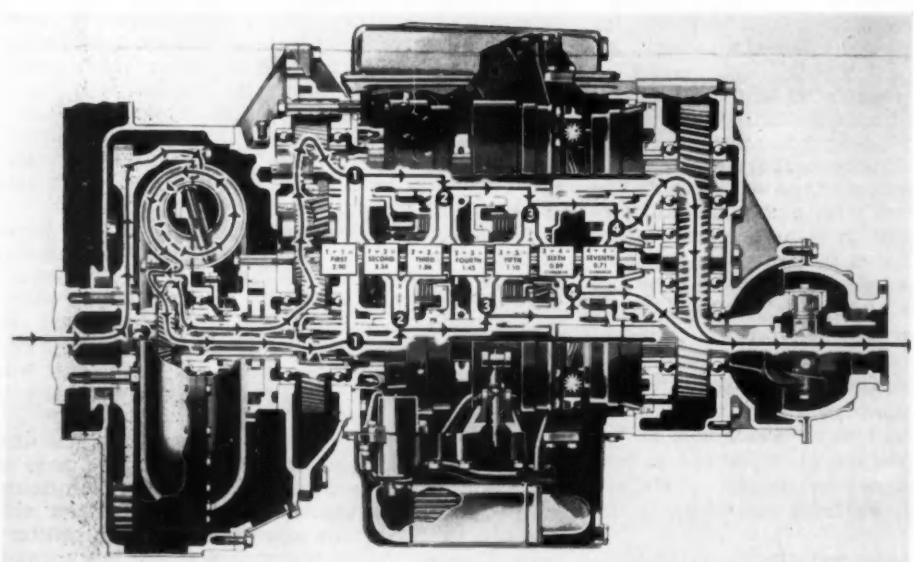


Fig. 1—One answer to the demand for automatic shifting in heavy-duty trucks is the GMC Twin HydraMatic drive, shown here in sectional view. Consisting of two HydraMatic units, one mounted above the other, this arrangement furnishes seven closely spaced forward ratios and a reverse

right into second when the driver shifts the auxiliary in direct. From this point on the automatic again will upshift to its seventh position for a total of thirteen shifts, assuming full throttle conditions.

Starting in "low" range, the automatic will shift to its seventh position. Then, as the driver selects "direct" range in the auxiliary, the transmission will pick up fifth speed automatically and continue its shifts to seventh position with full throttle. This maneuver takes only ten gear changes.

In the start in "direct" auxiliary, when possible (under favorable conditions), gear shifts are held to a maximum of seven.

Many passenger car torque converter type planetary gearing transmissions, with full torque shifting characteristics, are being "beefed up." That includes auixiliary gear units bolted to the main transmission for 1-ton, 1½-ton, and possibly 2-ton truck applications. However, the engineers in the advanced engineering groups are searching for the ideal truck transmission design for versatile coverage and volume production.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

What the Discussers Had to Say

F. K. Glynn,
American Telephone & Telegraph Co.

The greatest gain in operating costs will be in the reduced maintenance on clutches and transmission (present gear boxes). There should be positive reduction of rear axle maintenance with the automatic type of transmission.

The big question is how much of the above savings, if they exist, can be expected to be wiped out by the overhaul cost of the automatic transmission. This, of course, will depend upon frequency of overhaul cost and the extensiveness of such overhaul. Only trial will answer these questions.

Insofar as presently available units are concerned, they provide a limited number of power-take-off openings and in our fleets, they have need of multiple drives for the varied types and kinds of accessory equipment required to accomplish their work.

Howard L. Willett,
The Willett Co.

Automatic transmissions in trucks will increase the trade-in value of the truck after four or five years by the additional cost of the automatic unit. This has been our experience with two-speed axles. If such proves to be the case, there would be an advantage in their use, even if all other factors were without gain.

Lewis C. Kibbee,
American Trucking Associations

Many over the road operators are looking with interest toward the use of torque converters and/or automatic transmissions. Presently, they are hesitant that sufficient range of reduction can be obtained to permit operation on 6% ramps at loading docks and still afford road speeds of 60 mph with acceptable economy of overall fuel consumption. This skepticism is based on observations of results obtained in bus applications and extremely heavy off-highway operations. The over-the-road haulers just about spans these two extremes.

The operators are also asking why the automatic type cannot be designed with more simplicity so that road failures will not result in long towing charges due to inability of driver to help himself or to obtain competent repair at scene of breakdown.

The operator feels that the driver pay scale will not decrease and the automatic transmission must show inherent economies to offset its initial cost.

F. R. McFarland,
Packard Motor Car Co.

The torque converter cannot be expected to be a full substitute for gear reductions, but rather a beneficial supplement to gear boxes. It will provide a fine starting medium. Service experience on passenger cars has proved rather simple after initial instructions were provided, as is the case with any new unit.

O. K. Kelly,
General Motors Corp.

Application of automatic transmissions to the over-the-road long distance hauler is the most difficult. It is a rare driver that has the ability to use 21 speeds to the best advantage. But it's not too difficult to teach him advantageous use of range gears, if main shifts are made automatic, requiring no choice on his part.

The automatic type of shifting with a fluid coupling is more desirable than the torque convertor and gear box combination. That's because torque multiplication in converter will require bigger and heavier gears to take the driving forces. The coupling will provide equally smooth starts with smaller gears and less weight in the gear boxes. This will also mean less cost for equivalent capacities.

Combustion Terms

TERMS FOR USE IN OTTO CYCLE ENGINE COMBUSTION

NORMAL COMBUSTION

A combustion process which is initiated solely by a timed spark and in which the flame front moves completely across the combustion chamber in a uniform manner at a normal velocity. In such a process there is no sudden release of energy from the fuel-air mixture, nor are there any auxiliary sources of ignition from combustion-chamber deposits, hot spark plugs, overheated valves, or other hot surfaces within the combustion chamber. Engine roughness associated with high gas loads and mechanical deflections of engine components can accompany normal combustion.

ABNORMAL COMBUSTION

A combustion process in which a flame front may be started by hot combustion-chamber surfaces either prior to or after spark ignition, or a process in which some part, or all, of the charge may be consumed at extremely high rates. This term, therefore, includes any surface ignitions of the charge, and it includes ordinary knock or knock which is induced by surface ignition phemomena, either prior to or after spark.

SPARK KNOCK*

A knock which is recurrent and repeatable in terms of audibility. It is controllable by the spark advance; advancing the spark increases the knock intensity and retarding the spark reduces the intensity. This definition does not include surface-ignition induced knock.

SURFACE IGNITION (HOT SPOTS - COMBUSTION-CHAMBER DEPOSITS)

Surface ignition is the initiation of a flame front by any hot surface other than the spark discharge prior to the arrival of the normal flame front. The flame front or fronts so established propagate at normal velocities. This phenomenon can be further subdivided into preignition and postignition.

PREIGNITION

Surface ignition before the occurrence of normal spark.

POSTIGNITION

Surface ignition which occurs after the passage of the normal spark.

KNOCKING* SURFACE IGNITION

Knock which has been preceded by surface ignition. It is not controllable by spark advance. It may or may not be recurrent and repeatable.

RUN-ON

Continuation of engine firing after the electrical ignition is cut.

NON-KNOCKING SURFACE IGNITION

Surface ignition which does not result in knock.

RUNAWAY SURFACE IGNITION

Surface ignition which occurs earlier and earlier in the cycle. This phenomenon is generally caused by overheated spark plugs, valves, or other combustion-chamber surfaces. Generally it is not caused by floating deposit particles or deposits adhering loosely to the combustion-chamber walls. This is the most destructive type of surface ignition. It can lead to serious overheating and structural damage to the engine.

WILD PING

Knocking surface ignition characterized by one or more erratic sharp cracks. It probably is the result of comparatively early surface ignition from deposit particles

RUMBLE

A low-pitched thudding noise different from knock and accompanied by engine roughness. One of the causes probably is the high rates of pressure rise associated with very early ignition or multiple surface ignition.

*KNOCK - The noise associated with autoignition[1] of a portion of the fuel-air mixture ahead of the advancing flame front. The flame front is presupposed to be moving at normal velocity.

With this definition the source of the normal flame front is immaterial it may be the result of surface ignition or spark ignition

[1]AUTOIGNITION - The spontaneous ignition and the resulting very rapid reaction of a portion or all of the fuel-air mixture. The flame speed is many, many times greater than that which follows normal spark ignition. There is no time reference for autoignition.

Defined by CRC

DEFINITIONS of normal combustion and various kinds of abnormal combustion are presented in the accompanying chart from a report recently issued by CRC. These definitions were developed because of the wide differences of opinion among automotive and petroleum engineers as to what to call the various combustion phenomena they were investigating.

Abnormal combustion, according to the report, manifests itself in a number of different ways. In addition to spark knock there is a variety of forms of abnormal combustion in which a flame front is started either before or after the spark by a hot combustion-chamber surface, as shown in the chart. Through lack of understanding of the different phenomena of abnormal combustion, the term "preignition" grew to be applied to all forms of abnormal combustion other than knock. However, by definition "preignition" means ignition before the spark, whereas some forms of abnormal combustion are initiated after the spark or after the electrical ignition has been shut off.

Thus, part of the confusion has arisen from the use of the word "preignition" as a rigorous and specific technical term by some investigators and as a loose and ill-defined general term by others.

In studying the problem of better terminology, the CRC felt that the best way to resolve this confusion and arrive at a working basis for a common language was to use terms which were compatible with the current technology. In this new technology the term "preignition" is reserved specifically in its technically correct sense to mean ignition before the spark. It is thus one specific subdivision under "abnormal combustion" arising from "surface ignition," as shown in the chart. "Surface ignition" is a generic term covering all forms of abnormal combustion other than "spark knock."

It was recognized that the recommended substitution of the words "surface ignition" for the word "preignition" as a generic term for the various types of abnormal combustion would require an adjustment in thinking because of the long-standing use of the term "preignition."

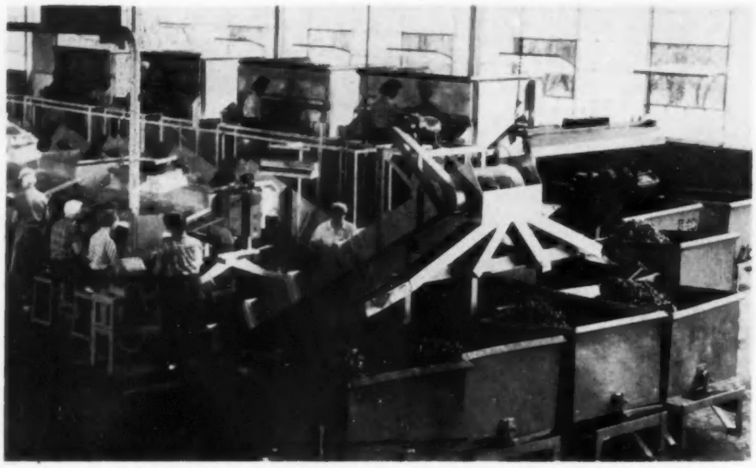
The technical committees of the CRC, at their meetings on June 8, 1954, approved the chart and definitions in the belief that:

1. Any changes in terminology should be made now rather than at a later time, when a change in usage would be much more difficult to accomplish.

2. The recommended terminology and definitions are suitable for use by both research men in the laboratories and road testers working with test cars.

As industry gains more knowledge of the causes and effects of abnormal combustion, there undoubtedly will be a need for changes in the chart. However the general use of the chart by industry will eliminate a major difficulty in the interchange of information and ideas on abnormal combustion, a field which is receiving concentrated attention from both the automotive and petroleum industries.

The report (CRC-278) was prepared by the Special Panel on Nomenclature, Combustion-Chamber-Deposits Group, Motor Fuels Division, CRC. It is available from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers. It consists of one page of text, which gives background and development of the chart, and another page, which contains the chart.

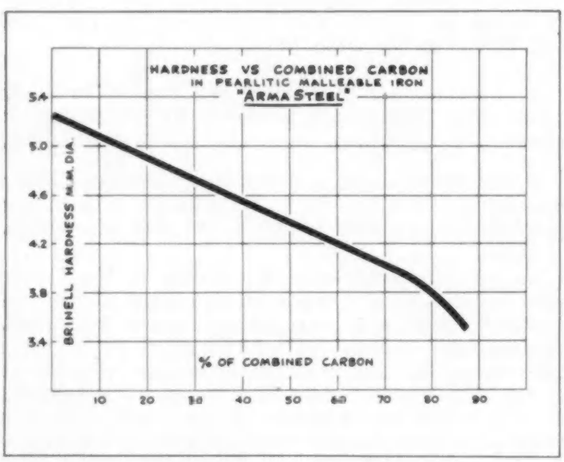


Eight electronic hardness testers operated by four girls in background check hardness of 20,000 Arma Steel rocker arms per hour. "Good" parts drop onto a conveyor taking them to girls in foreground for further inspection.

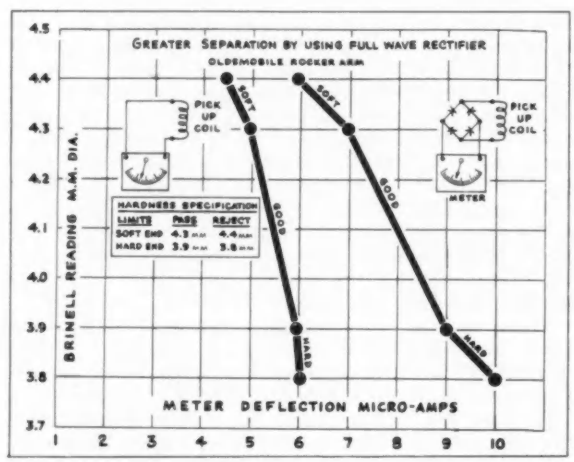
Central Foundry

M. J. Diamond, Research Engineer, Central Foundry Division, GMC

Based on paper "Magnetic and Resistance Methods Used in Non-Destructive Testing" presented at SAE Summer Meeting, Atlantic City, June 9, 1954.

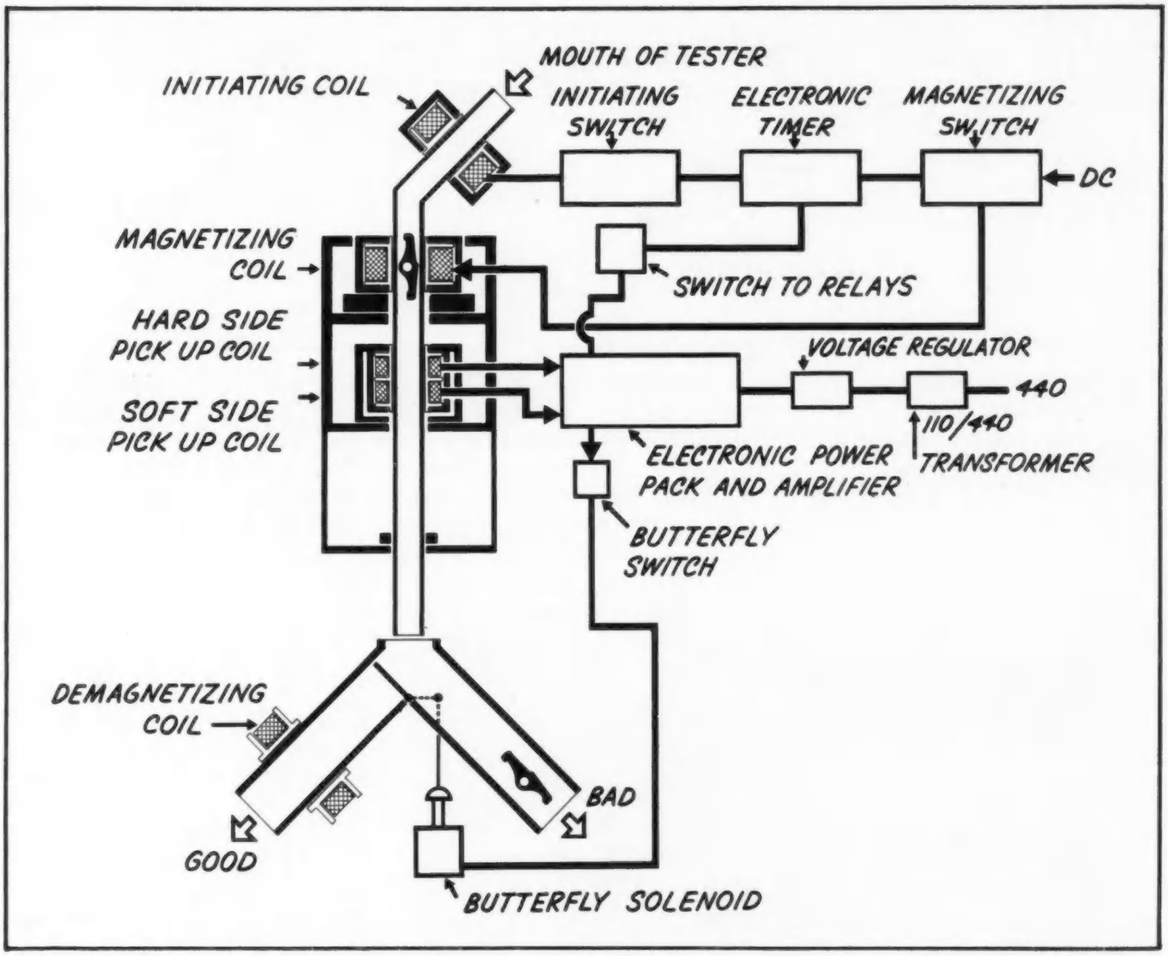


Percentage of combined carbon determines how Arma Steel will react to heat-treatment. Parts with too little or too much carbon in the iron metallographic structure must be discarded. Fortunately, not only does combined carbon correlate with hardness, but also . . .

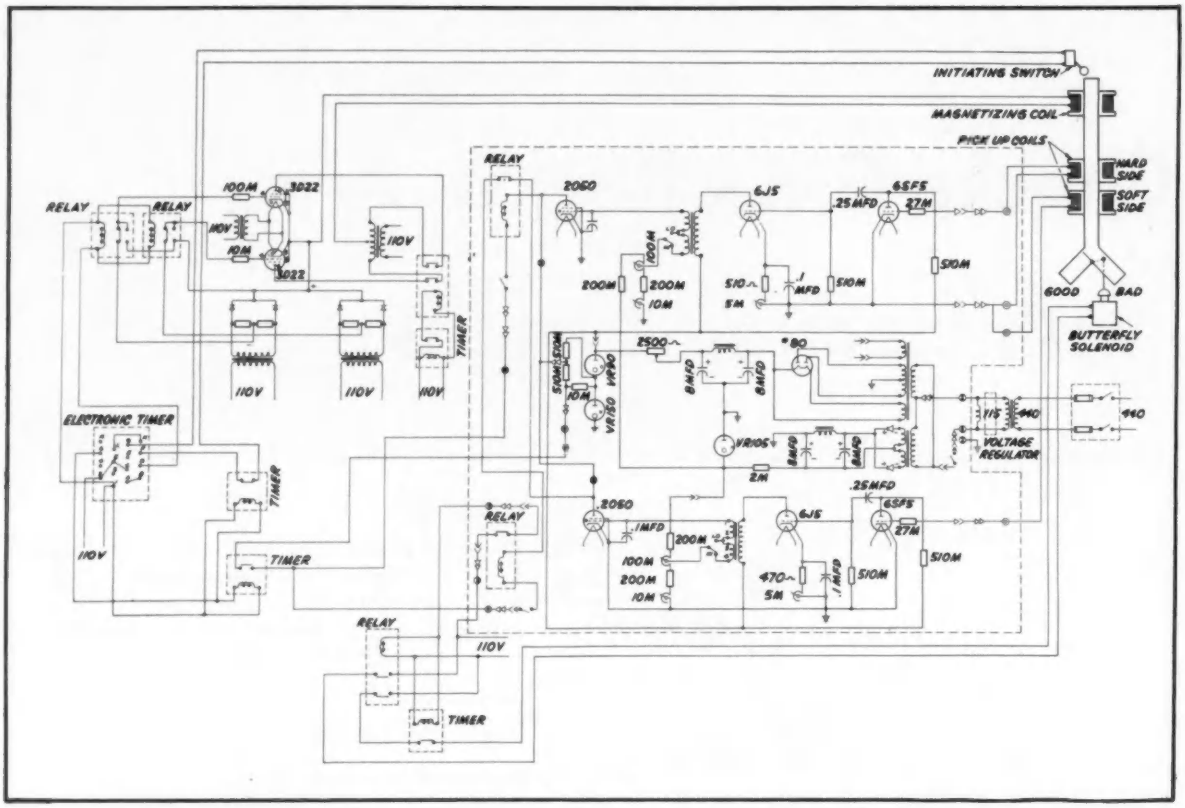


. . . **hardness correlates with magnetic retentivity.** This is the principle of the electronic hardness tester. A magnetized casting dropped through a coil generates an electrical impulse that will deflect a microammeter. In the actual electronic hardness tester . . .

Checks GM's Rocker Arms with Electronic Hardness Tester

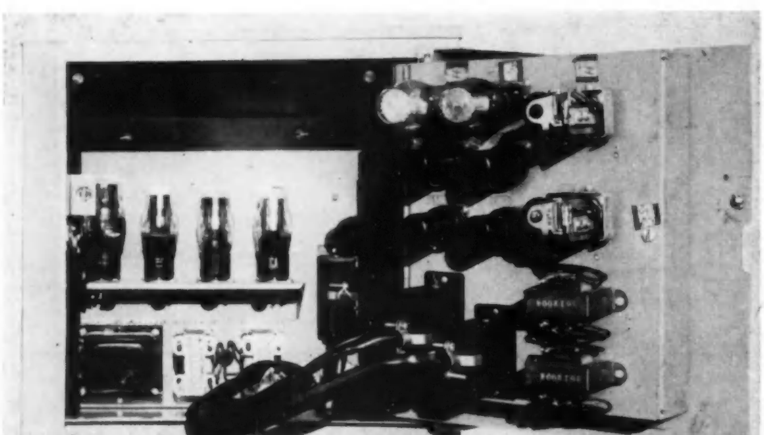


. . . **the rocker arm to be tested** is picked up by the inspector and dropped into a long plastic tube. Its passage through the first coil initiates a circuit for applying 125-v dc to the magnetizing coil for a timed period. The magnetizing coil holds the casting suspended for approximately 1/3 sec and saturates it. Then the magnetized casting falls through a double-wound pickup coil. If the casting is too hard, the first coil energizes a circuit whch closes the "good" exit. If it's too soft, the second coil closes the "good" exit. More specifically . . .



. . . each pickup coil feeds its electrical impulse to its amplifier. Each amplifier controls a thyratron tube, which in turn controls the butterfly pass-or-reject valve.

For calibrating the hardness tester, four castings are chosen by brinell testing such that one gives 0.1 mm brinell reading outside the prescribed soft limit, one is 0.1 mm within the soft limit, one is 0.1 mm within the hard limit, and one is 0.1 mm beyond the hard limit. The amplifier is adjusted so that it passes the two within the limits and rejects the two outside.



Brains of the tester are these tubes. On the right are the two amplifiers and their thyratrons. The power supply is at the left. Relays last about 2,000,000 operations, although their manufacturers originally rated their life four times that long.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Supervisory and Technical Personnel

Where to Find Them; How to Use Them

E. T. Hart, General Motors Corp.

Based on secretary's report of panel on Selection and Training of Technical and Supervisory Personnel held as part of the SAE Chicago Production Forum, March 29, 1954.

EXPANDING industry is confronted with a shortage of management and technical personnel. There is need for an ever-increasing number of trained men and an equally pressing need for extensive training of all ranks of supervision.

Twenty years ago, the foreman was not much troubled by budgets, cost control, labor contracts, employee relations, and the like. Now he must be familiar with, if not expert in, all these subjects to do his job effectively. Training him to meet these demands will make him a better foreman and pay off in a better running organization.

Today's job of developing a team breaks down into four parts:

1. Selection of the most apt, talented and best suited man.
2. Training the man for the peculiar skills needed.
3. Trying to improve the skills of the man who was poorly selected.
4. Following up to insure a man's proper placement.

Where to Find Good Men

The finding and proper assignment of men to take over supervisory and technical positions is a difficult task. Competent superintendents don't walk in off the streets; really effective foremen don't appear out of thin air. Yet they must come from somewhere, and they do. They come from all over the place—from work benches, from the job level just below, from colleges, and from other, sometimes rival, companies.

The colleges are supplying personnel in ever in-

Personnel Executives . . .

. . . formed the panel of experts who developed the discussions on which this article is based. They were:

Byron L. Stewart, Leader,
Delco-Remy Div., General Motors Corp.

E. T. Hart, Secretary,
General Motors Corp.

M. S. Firth,
R. R. Donnelley & Sons Co.

B. E. Kline,
Inland Steel Co.

J. A. MacLean,
Bendix Products Div., Bendix Aviation Corp.

T. H. Miller,
Eastman Kodak Co.

E. H. Reed,
International Harvester Co.

J. M. Scarlett,
General Electric Co.

A training program, no matter how efficiently and scientifically put together, cannot function to the best advantage unless there is full support by all members of management. All the charts, courses, schools, and conferences in the world will have little or no effect unless the entire management structure understands the necessity for such a program, is familiar with its procedures and does its part to make it effective. Management must be "sold" on the program and its cooperation must be made manifest by active participation in the program operations if the program is to be worth anything.

creasing numbers. The college recruiting program, now used by practically all large companies, draws to industry the best of the technical graduates. These men respond to the offer of a good job, well paid, with opportunities for advancement and a training program to insure getting ahead. Generalities may not move the prospective engineer to join your organization, but specific plans for the future may induce him.

How to Hold Good Men

To retain promising supervisory personnel you must show them the ropes, demonstrate the opportunities for advancement, and prepare them for the possible vacancy ahead. This is being done more or less successfully through training programs.

The kind of training program depends largely on the size of the organization and the peculiarity of replacement requirements. A small, non-expanding company may have a fairly simple program. A small, expanding company may have a more complicated one, while a large corporation will require a sizable, complex system of training. All need some sort of program if they are not to be faced with a problem when supervisory employees die, quit, or retire.

What Type of Training

Should training be done by the line organization or by specialists? Proponents for the line hold that the man doing the job is best qualified to teach because he is familiar with requirements. Those who believe specialists should be used, think skill in applying efficient testing and training devices and procedures is most important. Actually, a combination of the two has been found the best.

Should training be given on an individual or group basis? This depends largely on company needs and the objective of the training. Group training can be effective in disseminating information, training in human relations, explaining company policy and the intricacies of labor contracts. Here the specialist can be used to advantage. But individual training is important, too. The superior should take a hand and see to it that the man below him is well trained. It is not enough to suggest available lecture courses and technical discussions; the supervisor must play an active part. It isn't always done—sometimes it is impossible—but the need is recognized. As one expert puts it:

"I think the sort of unspoken aim of all of our group supervisory training programs is to get the supervisor to carry out individual development programs for the people under him. That is true from top to bottom of the organization."

Various Training Techniques

In preparing men for advancement, some organizations use industrial psychologists to guide and counsel those who supervise in the better understanding of the men under their control. Understanding why men react as they do helps the foreman or superintendent to handle situations which might become ticklish without that understanding. There is also need to understand the individual and his particular situation. Even a good workman is not at his best when plagued with domestic trials or financial difficulties. Playing the role of family counsellor is difficult for a supervisor, but to be aware of troubles is of inestimable help in the improvement of human relations.

It is almost impossible to achieve the desirable supervisor-subordinate relationship if the group is so large that the supervisor hardly knows the men's names or their personal idiosyncrasies. Employees work together better, know each other better, and feel more intimately associated with the company if they consider themselves an important part of a group, no matter how small. This sense of belonging is acquired better in small units where identity is not lost.

Examples of Group Handling

One company holds fortnightly meetings of supervisory personnel on what is called "current events." Emphasis is on labor relations. At each meeting a different group is brought up to date and information passes by word of mouth.

Another company uses a module conference plan. There are eight sections dealing with such topics as personnel administration, job planning, job problem, and so forth. Sections may be used singly or in combination. Specialists are used for some parts of the program, and material is provided to help in the conferences.

Now in development is a program in which supervisory personnel make up their own job programs, listing requirements of the job and outlining methods they think best suited to achieve training in those requirements. All information thus derived will be pooled to help in developing a successful company program.

Checking the Individual's Progress

Progress charts may be used though many people think them lacking in flexibility. Ordinary cards

are said to be more flexible. The main thing is to keep them up-to-date so that a man's status is evident at a glance.

Rating a Training Program

To measure the results of a training program, a factual rating can be made of what supervisory and technical people are doing on their jobs. Instead of relying on subjective opinion we can take a cold look at such things as:

What have our technical people developed that is new?
What have they done to improve a product and make money out of it?
What have they done in their design to facilitate tooling and manufacturing processes?

Of supervisory personnel we can ask such questions as:

Does he get quality and quantity?
Is he running his department efficiently?
What is his labor turnover?
What is his safety record?
Does he operate within his budget?
Do his employees turn in suggestions?
How much scrap is made in his department?
What about his use of tools and processes?
Does he know his people?
What is his grievance record; how well handled?

If a training program is aimed at things of this nature then all we have to do is examine the performance to know whether or not we are getting the job done.

Cost and Perfection . . .

. . . have to be balanced to decide the most economical quality level in any given instance. Frank advance talks between vendor and customer often help greatly.

Based on a Production Forum Secretary's Report by **Richard H. Ede,** United States Steel Co.

ONCE a design is set, the production department has to see that the manufacturing process conforms to it.

Although perfection is desirable, it is unecomonic. There is always a balance between cost and degree of perfection at which the quality level becomes most economical. This can best be determined by a frank discussion between vendor and customer, *whether it be between two companies or two departments of the same company.*

With a satisfactory quality level agreed upon, control charts become indispensable to maintain this level during processing. (Such charts result from obtaining the average and deviation—range or standard deviation—of successive small samples from various key points in the production line. From these figures, control limits are computed. When sampling indicates that a state of control exists, the measures of a process can be predicted.)

These control charts become a sound basis for making decisions, and can be made available to each department. Then, with all little decisions made better, less need arises for big decisions at the management level.

Startling benefits have come sometimes from the improved attitude of the operators after the installation of quality control charts. The control chart gives an operator a picture of his own work—and a chance to compare his results with others. Knowing that others, including his foreman, can do the same, the operator has considerable incentive to make his picture look as good as possible.

Quality control is applicable to all types of processing, even to job shops in which runs of material are too short to apply conventional methods. By placing charts on the variability of successive lots, machine capabilities can be found as accurately as by standard procedures. It has been stated that "one chart on one machine with one operation is equivalent to a one-man company—a job shop."

The ultimate goal in quality control, of course, is quality certification. So vendor and customer must be in complete agreement. They must agree on such items as quality levels versus costs. Classification of defects such as critical, major and minor must be defined, so the vendor may know exactly the quality level demanded in each division. Methods of obtaining samples for control charts should be discussed, so the customer can have confidence that the vendors' charts are statistically correct.

A plan should be given a sufficient trial to locate any "bugs" that might appear in routine operation.

Under such an agreement, a major portion of the vendor's outgoing inspection and the customer's incoming inspection is eliminated. In its place, the vendor furnishes a certified control chart with each lot of material shipped. The plan is almost certain to result in better quality at lower cost.

(The full Secretary's report of which this article is an abridgment is available as SP-306 along with reports of the seven other Production Panels held at the 1954 SAE Production Meeting in Chicago, March 29, 1954. Price: $1.50 to members, $3.00 to nonmembers. Chairman of this Panel was F. J. Dalton, Deere & Co. Members were L. A. Knowler, State University of Iowa; A. C. Richmond, International Harvester Co.; Arthur Bender, Jr., Delco-Remy Division, GMC; and W. E. Jones, Management Controls.)

How to Use Your Production Cost

HERE'S an important tip to keep you from fouling up your make-or-buy activities (whether to make a part in your own plant or to buy it from a vendor): Avoid being misled by normal methods of computing overhead. Use only increment costs, out-of-pocket costs, for comparison.

In our own operations, this one factor often is big enough to be decisive in "make Canadian" or "buy American."

By increment costs we mean those indirect expenses that are a direct result of entering into, or continuing the manufacture of, certain items. The increment cost principle is an accepted accounting technique for presenting costs to management for intelligently evaluating alternate courses of action. With it, the right decision is easy to make.

Here is the crux of the whole thing: Analyze for each choice all of the costs which will change if that choice is made. Eliminate from consideration those costs which will not change.

But remember that increment costs *do not* replace the normal, fully accounted costs used for product pricing. They merely set aside those fixed cost factors which don't change by adoption of either alternative and would be red herrings in choosing a course of action.

This simplified hypothetical case shows the effect of using these two methods of costing for comparison purposes:

Let's start with the accounted cost approach. The "make here" cost factors are as follows:

Material	$10.00
Labor	5.00
Total overhead (at 300% rate)	15.00
Total Manufacturing Cost	$30.00

Table 1—Make-or-Buy Analysis for Glove Compartment Door Made by Ford plant in Canada

Processes	Ford—Canada Simple, inexpensive dies with simple handling and inexpensive welding set-ups	Ford—U.S. Elaborate dies using automation devices for production 11 times that of Canada	Comparison
Tooling Cost	$12,500	$54,000	U. S. Is 330% Higher
Direct Labor per Door	3.22 min	1.15 min	Canadian Direct Labor 180% Greater
Total Increment Cost	$43,500	$62,900	"Make Here" Alternative Shows Saving of $19,400 or 31%
Total Fully Accounted Cost	$62,000	$60,800	By This Method, Buy in U. S. Shows Saving of $1200 or 2%
Cost Even Without 25% Duty (Increment Cost)	$43,500	$50,900	"Make Here" Shows $7,400 Saving or 15%

Figures to Reach the Right Make-or-Buy Decisions

W. P. Park,
Manager, Manufacturing Division Staff Services, Ford Motor Co. of Canada, Ltd.

Based on a report to a Panel on Reconciling Smaller Canadian Production to Larger U. S. Production in Automotive Field, of the Production Forum at the SAE International Production Meeting, Toronto, Oct. 29, 1953.

Now let's suppose that the "buy outside" consideration shows a vendor quotation of $26.00.

So comparing the two alternatives by the accounted cost method shows it would be wiser to buy outside.

Now let's take a look at what the increment cost approach shows. The "make here" analysis shows the following:

Material	$10.00
Labor	5.00
Variable overhead (specifically analyzed)	10.00
Increment cost	$25.00

A glance at the "buy outside" figures reveals the following:

Vendor quotation	$26.00
Inbound freight and receiving expense (specifically analyzed)	2.00
Increment Cost	$28.00

It's apparent from this second analysis that the "make here" alternative is the wiser dollars-and-cents answer because the out-of-pocket cost is lower. The increment approach shows that $5 of the 300% overhead rate is made up of fixed expenses incurred regardless of this particular decision.

The same basic theory applies to alternative choices involving capital expenditures. We use increment costs when an accurate savings picture is needed on new machine purchase versus old machine retention. We recently used such a specific analysis. It was based on proved savings in making our own castings in the past and careful estimates of future casting of our own cylinder heads, shell-molded valves, and nodular iron crankshafts. The analysis justified a multimillion dollar foundry expansion program that's now well under way.

Costs developed by the increment principle are invaluable for management guidance. That's because they are analyzed for a specific use and contain only essentials. This value of increment costing was driven home to us in a comparative cost analysis we made on the glove compartment door. The operations involved consist of blanking and forming the inside and outside panel and assembling them by clinching.

Table 1 forcefully illustrates the danger of using fully accounted costs for comparison purposes.

In Ford of Canada, we processed this job for simple, inexpensive dies with simple handling methods and inexpensive welding set-ups. Ford in the United States naturally used elaborate dies with automation devices for their higher volume, 11 times that of ours. Our tooling cost only $12,500; theirs cost $54,000, or 330% more.

As a result, our direct labor per part is 3.22 min, whereas theirs is only 1.15 min. But when you consider all applicable costs in both situations ($43,500 for the "make here" alternative and $62,900 for the "U. S. purchased" doors), the "make here" assembly is $19,400 or 31% cheaper.

If we had used the fully accounted cost for comparison, the "make here" cost of $62,000 would have been $1200 more than the "U. S. purchased" assembly cost of $60,800. That would have led us to decide erroneously to buy the door from the States.

(The full text of this report, along with that of the secretaries' reports of the seven other panels at this Production Forum, is available from SAE Special Publications Department, as SP-305. Price: $1.50 to members, $3.00 to nonmembers.)

6 Statements On

R. R. Peterson, Chrysler:

1 EFFICIENT AS the suspension is in filtering out high-frequency disturbances, it tends to excite vibrations in the 8-15 cps range.

Fig. 1 shows how suspensions develop oscillatory modes of their own. The weights and spring rates involved show secondary systems having natural frequencies in the shake range, generally around 8 or 10 cps. They are less efficient as filters than the primary or sprung mass system.

The near-realistic diagram of a typical front suspension shown in Fig. 2 has a single vibration mode, essentially vertical wheelhop. It is reasonably efficient in filtering out vibrations. On the other hand a rear suspension has six vibration modes, all with natural frequencies within the shake range. The major modes—parallel hop, tramp, and wind-up—are not strong direct exciters of shake. Their real significance lies in inducing vibrations in the minor modes—yaw, lateral shift, and fore-and-aft shift—which in turn are powerful shake producers.

The minor modes have several things in common. Direct excitation by road disturbances is weak. The springing which governs their natural frequencies is the same (at least of the same order of magnitude) as that governing their isolation frequency. Therefore they are subject to high transmissibility. In fore-and-aft shift and yaw the condition is practically one of resonance, and damping is small. These two natural frequencies are much the highest, and resonant amplitudes are not readily excited by vibrations in other modes. Nevertheless, considerable longitudinal shake excitation is produced.

Vibration energy is shuttled between various unsprung mass modes in many ways. The coupling between hop of a single wheel and yaw of the axle is a simple case. The strongest coupling is between tramp and lateral shift where three factors operate

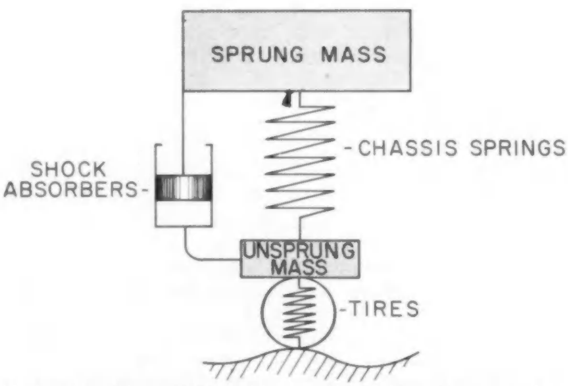


Fig. 1—This schematic picture of car suspension shows how suspensions develop oscillatory modes of their own. Secondary systems are less efficient as filters than the primary, or sprung mass system.

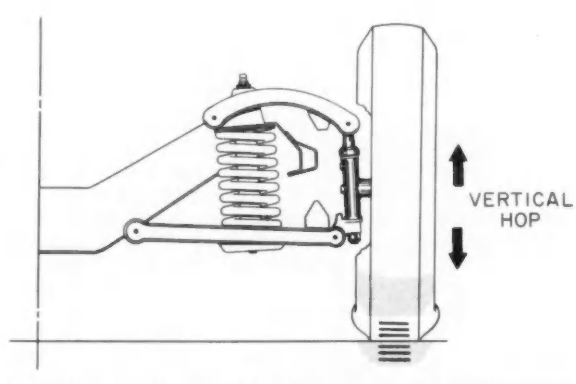


Fig. 2—Here is half a typical front suspension or actual realization of the scheme shown in Fig. 1. It has a single vibration mode, essentially vertical wheelhop, and is fairly efficient in filtering 8-15 cps shake.

CAR SHAKE

in concert to produce sizeable lateral shift oscillations.

Various types of lateral links have been attached between rear axles and frames to combat shake. Some are rather flexible, others rigid, and still others incorporate a shock absorber to provide lateral damping. The last two are more effective than the first. A "sea leg" is fairly effective and inexpensive. Softer tires can help, providing the softening is in the radial direction only—and that's difficult to achieve. Independent rear suspension would approach a complete solution, but at a prohibitive cost.

L. H. Frailing, Packard:

2 FLEXIBLE ENGINE mountings can and do cause shake. It's virtually impossible to produce mounts that transmit no engine impulse or torque to the frame.

At least, it's virtually impossible to achieve this in a mount that transmits no vibration set up by the wheels or propeller shaft back to the engine. Engine mounts have to be a compromise transmitting the least possible vibration in either direction.

The best compromise is usually a soft engine mounting system. This can be explained by reference to the transmissibility curve, Fig. 3. To get low transmission of the engine firing frequency, during idle or torque reaction periods throughout the speed range, from reaching the frame it is desirable to have the ratio of disturbing to natural frequencies high. If we consider an 8-cyl engine and an idle speed of 400 rpm, the frequency would be 27 cps at that speed. If a frequency ratio range between three and four is selected as the minimum portion of the abcissa of the transmissibility curve, then the natural frequency of the mounts in the vertical plane would vary from 9 to 6.75 cps.

We know, however, that wheelhop resonance varies on most vehicles over a range of 8 to 12 cps. Obviously the engine's natural frequency on its mounts should not be in this range or transmissibil-

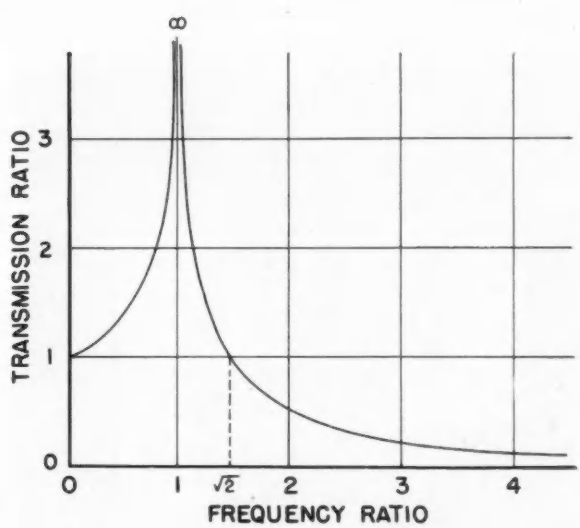


Fig. 3—This transmissibility curve shows the desirability of having a high ratio of disturbing to natural frequencies if the transmission of engine firing frequency to frame is to be kept low.

ity would become very high, resulting in bad structural shake.

Going to softer mounts introduces another difficulty when the forced vibration of the primary motion set up by the contact of the wheels on the road coincides with the lowered natural frequency. To preclude this possibility the frequency should be at least 13 to 15 cps.

M. Ruegg, General Motors:

3 RIDE EXPERTS use the bump rig to reveal wheelhop, front wheel fight, rear axle side shake, and power hop. They use the shake rig to uncover shake in the frame-body-powerplant combination.

Fig. 4—This bump rig is a handy tool for tracking down suspension-caused shake such as wheelhop, front wheel fight, rear axle side shake, and power hop.

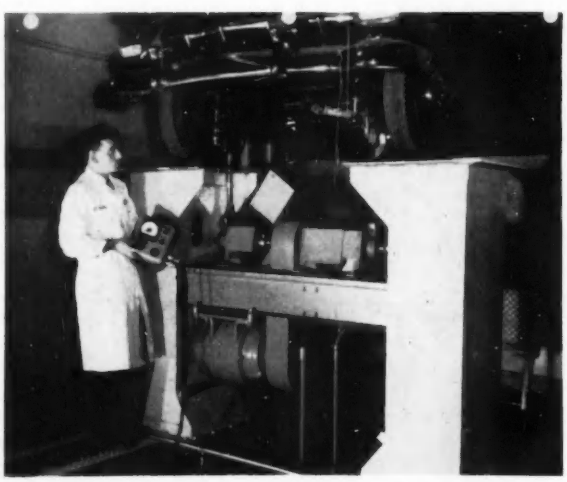


Fig. 5—Shakes in the frame-body-powerplant combination are studied with this shake rig. Bump and shake rigs here illustrated are used at General Motors Technical Center.

The bump rig (Fig. 4) consists of two rolls supporting front and rear wheels. The rolls are 4 ft in diameter, and rim width is 17 in. Upon the rolls are mounted aluminum cams, or bumps. The cams can be of various amplitudes but ⅜ in. is adequate. One roll can be rotated relative to the other. With cams in phase we get parallel hop; out of phase gives tramp.

The shake rig (Fig. 5) has a connecting rod on either side attached with ball joints to a convenient part of the suspension. The lower part of each rod is driven by an eccentric on each end of a through shaft, which in turn is driven by a variable-speed electric motor.

The eccentric may be in phase or 180 deg out of phase, and the rig can be driven at any speed up to 1700 rpm. At speeds higher than 1400 rpm the shake reactions become violent, and reduced input amplitudes are in order.

The bump rig is used first to track down suspension shakes, which are then eliminated as far as possible. This is important if the shake rig is to be beneficial. Front and rear ends are tested separately on the shake rig and with the eccentrics in and out of phase. While the bump rig requires accurate recording mechanisms, the shake rig recording is done by a trained observer.

The bump rig simulates a washboard road excellently—less well the average road with unevenly spaced bumps. But the suspension will respond to most impacts having a 500 to 800 cpm frequency.

The shake rig does not necessarily simulate road conditions. It reveals any structural shakes in resonance with the critical frequencies of the suspensions. Once resonance has been determined, remedies can be worked out, chiefly by tuning and compromising.

R. J. Saxon, Ford:

4 A COMPUTER that tabulates the frequency of occurrence of several amplitudes of shake has proved to be a speedy means of measuring shake on the road.

What's more, the computer's results agree closely with observers' impressions.

You could get the same results by using a vibration pickup and recording oscillograph, then examining the oscillogram to determine the frequency of occurrence of amplitudes. But it would take a trained analyst days to analyze data accumulated in a few hours of road testing. The computer rides along in the back seat and has the data all analyzed at the end of the run.

It is an electronic selective threshold analyzer—ESTA, for short. Essentially it consists of a vibration pickup that produces a signal proportional to the velocity of vibration. The signal is put into the ESTA, which integrates it to produce a voltage proportional to the amplitude of vibration. This amplitude-proportional signal is amplified to energize a

series of threshold controlled counters which are adjustable and preset to values ranging from small to large shake amplitudes.

The vibration pickups are simply mounted on the fenders and hood with clay. A gasoline motor-generator placed in the luggage compartment powers the system. When a shake of a given amplitude occurs, the signal from the vibration pickup causes one or more of the counters to operate. During the length of the run the counters totalize the number of times the shake amplitudes exceed each of the threshold values. ESTA does the analyzing and tabulating, but it still can't think. The hope is that by freeing engineers' time for thinking, shake problems can be solved faster.

Mark Garlick, Pontiac:

5 AS A first step in solving shake problems, passenger car structures are subjected to deflection and torsion tests to determine their stiffness.

If a proposed design shows stiffness values comparable to those of an older, satisfactory model, chances are that the proposed design will also be satisfactory.

For beaming, or bending, tests, the car frame is supported at the front axle center through the lower suspension arms by means of solid spacers in place of springs. At the rear axle line it is supported by knife edges applied to beams substituted for rear springs and loosely pinned and shackled. Coil springs would have support through the spring supports in line with axle center.

The load may be applied hydraulically or by static weights evenly distributed between front and rear seat positions, so that deflections resulting from a 1500-lb load may be recorded at front axle, dash line, body bolt positions, rear axle, and end of frame.

The torsional test setup is similar except that supports under front axle points are carried on scale platforms. Load change torsionally is applied by adjustment of jacks to twist the frame. Indicators are placed at conventional distances from car centerline to permit calculation of twist in degrees at significant planes.

Typical values of beaming deflection for frame, and frame and body are shown in Fig. 6. Arrows indicate relative position of load applications. The torsional deflection curve (Fig. 7) indicates deflection in degrees of twist per 1000 lb-ft torque. Here the added stiffness of the body decreased deflection to about one-sixth that of the frame alone. It shows the relatively great structural potential of the body and explains why a little change in body structure may require drastic frame compensations to maintain standards.

Information gained from these tests, coupled with road observation, can be applied to get a satisfactory body structure without the penalty of unnecessary frame weight. Sample frames can be checked to reveal deficiencies in bending or torsion. Then, gains to be had from reinforcing can be weighed against cost and weight penalties and the adopted practice appraised directly.

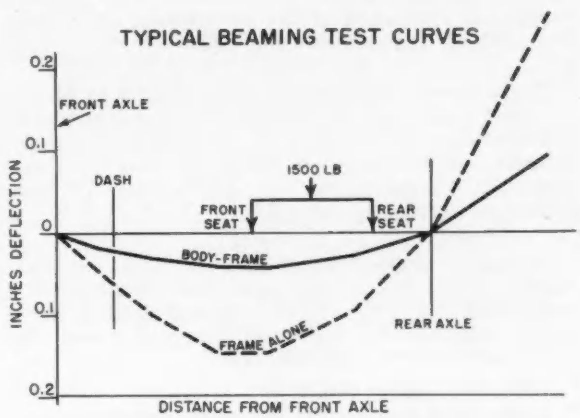


Fig. 6—These are typical values of beaming deflection for frame and for frame and body. Arrows indicate relative position of load applications.

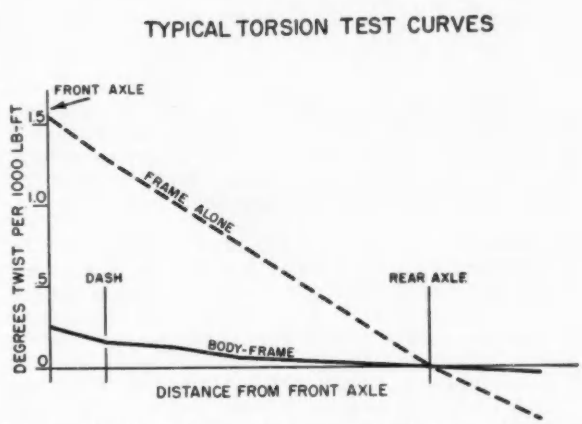


Fig. 7—Deflection in degrees of twist per 1000 lb-ft torque is shown on this torsional deflection curve. The great structural potential of the body stands clearly revealed.

M. Kamins and W. B. Love, Studebaker:

6 CONVERTIBLES REQUIRE extra precautions against shake because they lack the structural stiffness imparted by a steel top.

Here are some of the things done to alleviate the convertible shake problem:

Tires—Use a lower pressure. A reduction of 2 psi, for instance, causes a 9% reduction in deflection rate of a 7.10-15 tire. The lower spring rate also

results in a lowered natural frequency of the unsprung masses of the suspension. This usually moves the frequency of the disturbance away from the critical frequency of the body.

Suspensions—The spring rates should be as low as other conditions will allow. This will minimize transmission of suspension disturbances to the chassis. A minimum of unsprung weight is also desirable. Good lubrication, particularly of leaf-type rear springs is helpful.

Stabilizer Bars—These are effective on some models when used front and rear. Sometimes a rear track rod is beneficial with a Hotchkiss drive. Some help can be had from diagonally mounted ("sea leg") rear shock absorbers.

Frame Stiffening—This is almost universal practice. A few producers use an X-member exclusively on convertibles. However, the gain is restricted because of the added harshness.

Other Devices—Additional means for controlling shake are extra bracing at top and bottom corners of the cowl section, more rigid attachment to frame at front of body, a sheet metal box section under floor pan outside the frame rails on both sides, a plywood bulkhead in the trunk, extra hold-down points, special hinge and lock mechanisms, torsion brace from radiator core support to the cowl, and vibration dampers. (The problem with vibration dampers is where to place them.)

The car engine is a promising absorber. The mass is ample, and proximity to the cowl makes it ideal. In a crude test setup shake amplitude was reduced 25% and the drawback of added engine noise and vibration seemed not too great.

Even steel wire braces running diagonally across the top when it is raised give some help in shake control.

Questions and Answers from the Forum

QUESTION: In bump rig testing, experimental engineers frequently mistrust the bump rig because it introduces a steady state condition which does not look like the transient condition experienced on the road. How have you overcome this condition?

ANSWER: Transient conditions cannot easily be reproduced on the bump rig. The transient, consisting of a damped free vibration superimposed on a forced vibration disappears very quickly, so that in a practical way, the steady state vibration only will be observed on the bump rig. For shake investigations, this is not of importance, as the free vibration frequency is covered when investigating the car at wheel hop frequency.

QUESTION: Doesn't reducing tire pressure in captive shake tests change the basic wheel hop frequencies?

ANSWER: Not on the shake rig. The unsprung mass frequencies are entirely determined by the speed of the rig and are independent of their elastic medium.

QUESTION: How can the constant-amplitude excitation provided by the shake rig be accepted as representative or even useful when the road gives excitation amplified by the response characteristics of the suspension.

ANSWER: The shake rig is not intended to represent road conditions. It is used merely as an exciter to determine the various resonance frequencies of different elements of the car structure that might time into the critical frequencies of the suspension.

QUESTION: Inasmuch as shake is primarily a dynamic problem involving small deflections, why do experimenters working with the structural aspects of the problem concentrate on static testing involving relatively large deflections?

ANSWER: Large deflections are a convenience when taking measurments of this type, and up to the yield point of the frame, they correctly represent the frame strength dynamically. The magnitude of static deflection is duplicated occasionally on the bump rig.

QUESTION: How does the "wrap-around windshield" affect body stiffness

ANSWER: There was no change in stiffness when 1954 "wrap-around windshields" were installed experimentally on a number of 1953 bodies from one manufacturer.

QUESTION: What is the effect of use of thicker rubber on vibration isolation?

ANSWER: Isolation is increased by adding to the thickness of the rubber.

QUESTION: What are the objections to independent rear wheel suspensions and why do European cars find it possible to install them?

ANSWER: The principal objection is to the increased cost. To mention only a single item, the soft ride of American cars requires the drive line joints to be capable of large angular movements. Stiffly sprung European cars need much less in

the way of angular capacity, and less costly joints are therefore used. It is true that independent suspensions do tend to decrease shake problems by eliminating most of the unsprung vibration modes.

QUESTION: Do lower spring rates reduce frequency and amplitude of wheelhop?

ANSWER: Lower spring rates reduce frequency but not amplitude. Amplitude may be increased by lower spring rates. In general, the lower the spring rate the lower the response. In front wheel suspensions, lowering the tire rate has a greater effect on wheelhop than corresponding change in suspension spring rate.

QUESTION: Would it not be more nearly correct to say that the suspension components are really the *cause* of the secondary vibrations rather than systems which may aggravate the seriousness of these vibrations?

ANSWER: Yes, the statement is correct, bearing in mind that the original source of the vibration is energy from the road surface.

QUESTION: What is the best method of isolating engine vibration when weight and rigidity cannot be changed?

ANSWER: A change of rubber compounding or hardness or both will affect isolation.

QUESTION: Why do you restrict your attention to the simple vertical mode of vibration of the engine on its mounts? Why not consider also, for example, coupled modes such as the roll-lateral mode?

ANSWER: All of the six known phases of engine movement should be considered in any analysis. We chose to discuss only the vertical phase for the sake of simplicity.

QUESTION: In a given installation of engine mounts, how do you know whether the engine is acting as a dynamic vibration absorber, or as an enhancer of secondary vibrations?

ANSWER: By installing vibrators on the frame front cross member to run through the range 300 to 2000 cps and placing pick ups on both the frame and engine, data can be obtained from which curves can be plotted that show resonant frequencies.

QUESTION: Have you investigated the ESTA's errors resulting from electrical integration or differentiation of an excitation which is not simple harmonic or steady state?

ANSWER: Within the frequency limits set up in our definition of shake, there are no serious inaccuracies introduced by the electronic integration. Actually, when the shake condition exists, the motion is substantially simple harmonic. No harmonic analysis is found to be necessary.

This article is based on six papers and an open forum at the SAE National Passenger Car Body & Materials Meeting, Detroit, March 4, 1954. The papers and the authors are:

"The Effect of the Car's Suspension on Car Shake" by R. R. Peterson, Chrysler Corp.

"Flexible Engine Mountings Can Cause Car Shake" by L. H. Frailing, Packard Motor Car Co.

"Laboratory Simulation of Car Shake" by M. Ruegg, General Motors Corp.

"Measuring for Car Shake" by Robert J. Saxon, Ford Motor Co.

"Structural Properties Needed to Suppress Car Shake" by Mark Garlick, Pontiac Motor Div., General Motors Corp.

"Shake Control on Convertibles" by M. Kamins and W. B. Love, Studebaker Corp.

Questions and answers from the open forum were reported by:

Maurice de K. T. Kennedy, Thompson Products, Inc.

These papers are available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ each to members, 60¢ each to nonmembers.

QUESTION: How do you control excitation so that the ESTA's results will be comparable from car to car?

ANSWER: To make the results comparable, the cars are driven over the same road surfaces, both on the test track and on the public highway.

QUESTION: How much does the ESTA weigh?

ANSWER: ESTA weighs 125 lb. The motor generator set in the trunk compartment which produces 110-v output, weighs slightly less than 100 lb.

The Napier Nomad

. . . a diesel compounded with compressor

THE BRITISH firm of D. Napier & Son Limited has compounded a diesel engine with an axial-flow compressor and a turbine to produce an aircraft powerplant very economical to operate. The powerplant is the Nomad, planned particularly for air cargo operations.

Air passes through the compressor, then goes to the diesel. The diesel exhaust goes on to the turbine to give up more of its energy.

All three components—the diesel, the compressor, and the turbine—are in effect coupled together to form a common mechanical system. This provides flexibility in the choice of operating conditions for best performance over the whole speed range.

Besides, it's the lightest arrangement. Actually compressor and turbine are connected solidly together. The reduction gearing joining them to the diesel needs to be only heavy enough to transmit the difference in power produced by the turbine and that required by the compressor.

Specific fuel consumption of the compound powerplant lies between 0.326 and 0.350 lb per hp-hr over most of its operating range. The powerplant was designed to run on relatively cheap diesel fuel but runs equally well on aviation kerosene or on wide-cut gasoline. Specific weight of the powerplant is well below 1 lb per propeller shaft hp.

The Nomad's fuel economy makes it an outstanding powerplant for both civil and military airfreight operations. The engine is powerful enough to give the speeds civil air cargo operators want, even on a scant diet of low-priced fuel. And it provides payload-range characteristics attractive for military troops and cargo carriers at least up to the altitude where pressurization becomes necessary. (Higher altitudes don't matter because the large apertures these carriers need make pressurization too difficult to be practical.)

The Nomad is a fine powerplant for search-and-rescue craft also. It is well suited to long flights at low altitudes and low flight speeds. Just as important, the pilot can change his flight plan at will without significantly altering fuel consumption or range available.

The diesel engine has 12 cylinders in banks of six, horizontally opposed on a six-throw crankshaft. Attached to the free end of the crankshaft is a torsional vibration damper of the viscous fluid type. It isn't required for normal operation, but it protects the engine in case one cylinder cuts out. The dry liners are of chromium-copper material chromium-plated on the bores.

Spark plugs are used for starting the diesel. Starting power comes from an electric motor.

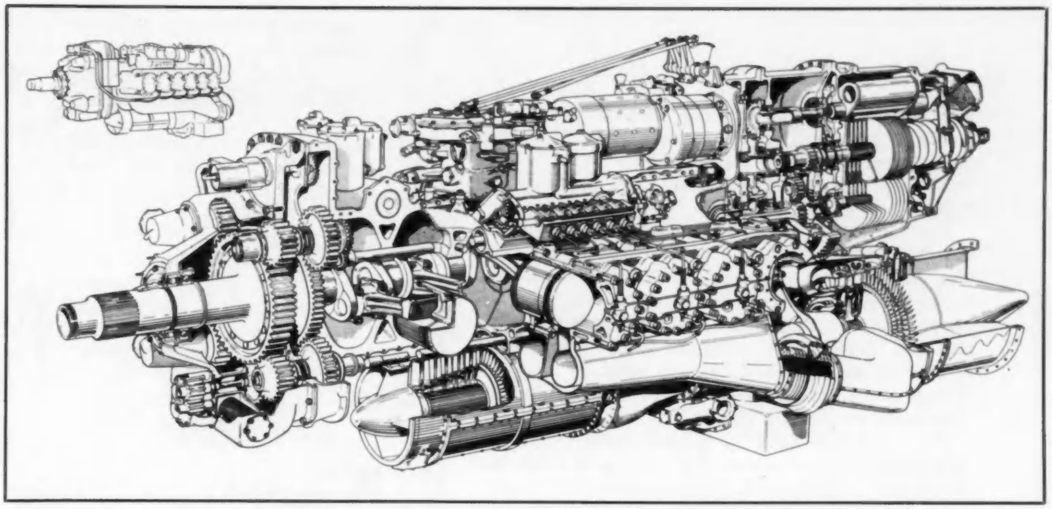
The axial compressor has 12 stages. It operates at a maximum pressure ratio of 8.25 : 1 with an air mass flow of 13 lb per sec. Adjustable inlet guide vanes extend the operating range at low speed.

Adiabatic efficiency of the compressor is 85% at sea level static conditions, and 87.5% at optimum conditions.

Turbine efficiency is 84% at sea level static conditions and 86% at the altitude cruise rating.

An infinitely variable gear makes it possible to speed up the compressor and increase its mass output as altitude increases and diesel engine speed remains about constant. This prevents diesel power from falling off as altitude increases.

Details of the Nomad appear on the following pages.

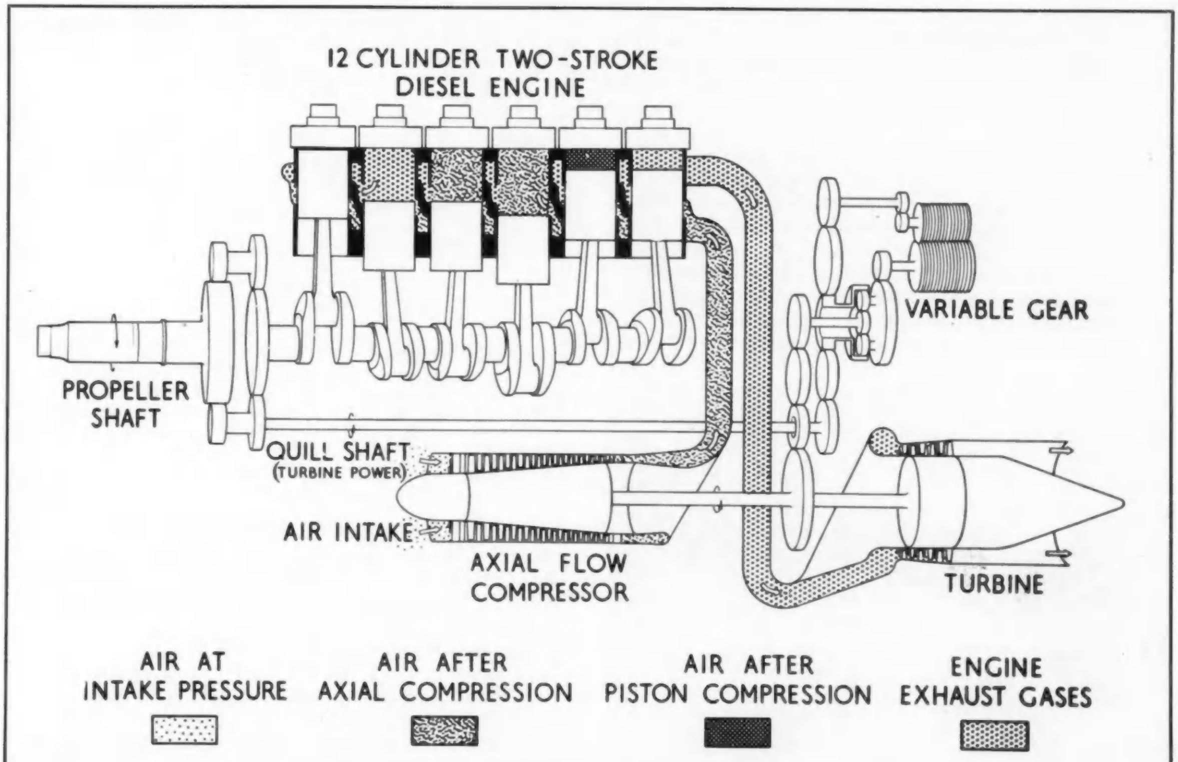


plus turbine for aircraft use

Herbert Sammons and **Ernest Chatterton**

Managing Director — Chief Engineer, Piston Engine Division, D. Napier & Son, Limited

Based on paper "The Napier Nomad Aircraft Diesel Engine" presented at SAE Summer Meeting, Atlantic City, June 10, 1954.



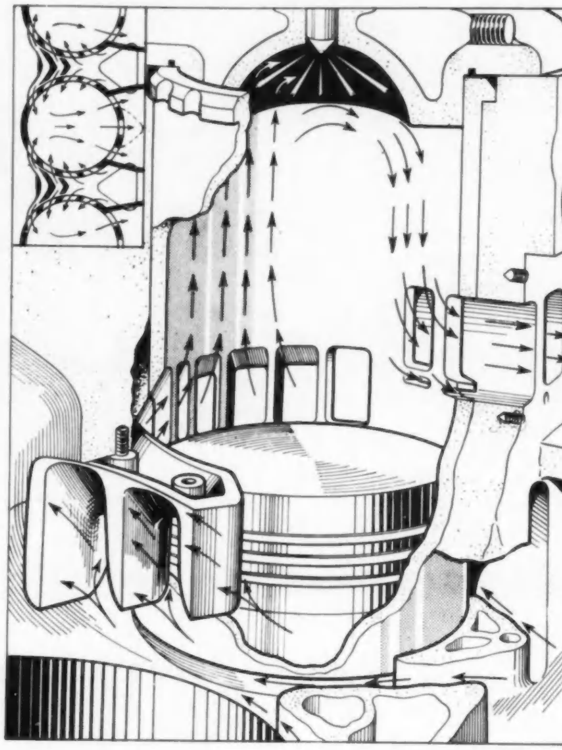
Cylinder design of the 12-cylinder, horizontally opposed diesel engine is of the simplest possible two-stroke-cycle type. The ports are piston-controlled, and there is no valve gear of any kind.

Incoming air is directed against the cylinder wall with an upward movement towards the combustion chamber. This air flow not only gives effective scavenging of burned gases from the cylinder, but also its well organized flow path permits high mass flow with minimum areodynamic loss.

The combustion chamber is hemispherical. The injector at the midpoint has one central orifice and five equally spaced radial orifices. The unusual feature of the design is that the sprays are directed at the combustion chamber walls—a feature that experience has proved beneficial.

The injector pumps, which are in blocks of six, are of "jerk-pump" design, specially developed to deal with high outputs and high speeds.

The pistons have alloy bodies and austenitic steel tops. They are designed to operate at 1100–1300 F at the center of the crown at full power. Oil sprayed against the inner diameter of the piston-ring band keeps ring-area temperatures down.

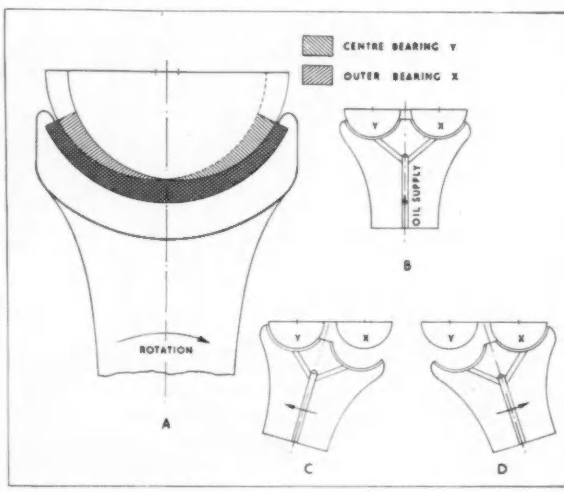


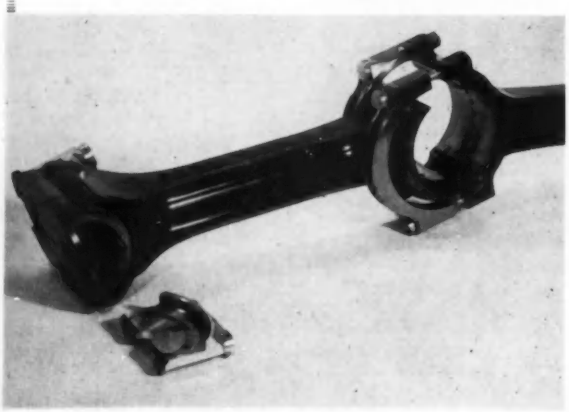
Slipper bearings take the practically unidirectional loading on the connecting rods resulting from two-stroke operation. Light straps take care of the forces in the opposite direction.

The bearings at the small end of the rod are specially designed to insure ingress of lubricating oil. Otherwise the bearing surfaces might starve because of the low rubbing velocities and the lack of separation of surfaces due to the unidirectional loading.

The bearing is divided into three half rings, the outer two being bearings **X** and the inner one bearing **Y** in the diagram. The outer bearings are coaxial, and their center is displaced transversely from the center line of the connecting rod. The axis of the center bearing is similarly displaced on the opposite side of the connecting rod axis.

The distance between centers of these bearings is only 0.035 in. But in the diagram it has been enormously exaggerated to illustrate how the connecting rod rocks on the crank journal. This rocking separates the surfaces and admits the lubricating oil.



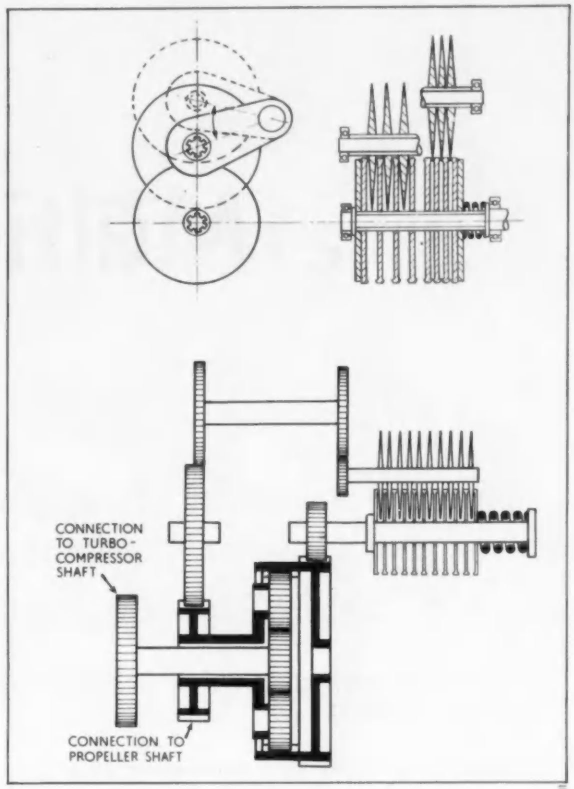


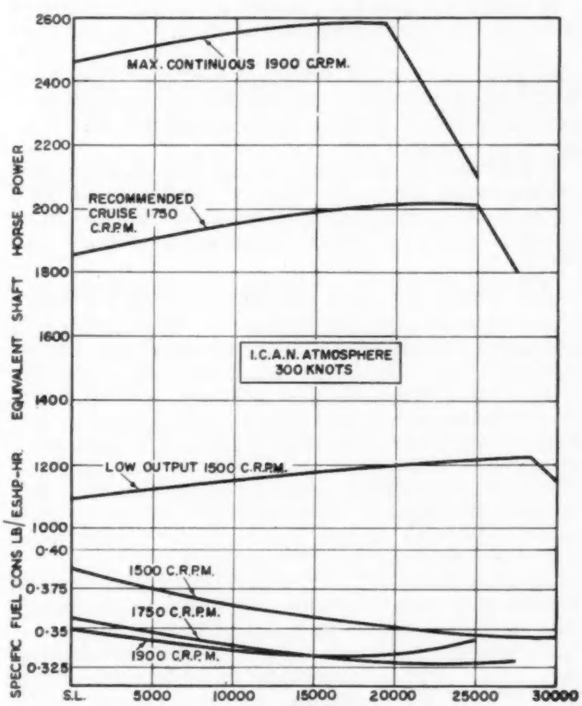
The infinitely variable gear makes use of the well-known scheme in which two conical members are end-loaded together, the gear ratio being varied by sliding one cone over the other.

The upper sketch shows how a pack of discs with narrow conical rims is mounted on a central shaft and spring-loaded to trap coned discs carried on a planetary shaft. The planetary shaft swings about a fulcrum to obtain changes in gear ratio.

By attaching a gear to the planetary shaft meshing with one at the fulcrum, one can arrange a constant-mesh gear system in which changes in gear ratio can be made while running. In the Nomad, three shafts with disc packs are disposed around the center shaft. The drag force between the discs is obtained by fluid shear of the oil film at the contact points. The end loads are adjusted according to the lubrication conditions to obtain the most efficient operation.

The lower sketch shows how the variable gear fits into the Nomad's gear system across two members of the turbine-compressor epicyclic speed-reducing train. This, in effect, gives two mechanical systems in parallel. Only about 30% of the total power passes through that part of the system in which the speed-varying device lies.





Cruise curve shows that the most economical specific fuel consumption of 0.326 lb per hp-hr is achieved at 22,250 ft with the compressor operating at 1750 rpm. Output is 2027 hp under these conditions, and brake thermal efficiency is 42%.

The flatness of the curves indicates how well the engine maintains its efficiency over a wide variety of operating conditions.

At sea level static conditions, turbine power balances compressor demand at 1500 rpm. At lower speeds the compressor takes more power than the turbine generates, and the diesel makes up the deficiency. At normal cruising conditions, the turbine supplies more power than the compressor requires.

The engine has a single-lever control system which relates power to rpm. A constant-speed unit varying propeller pitch controls rpm. Each rpm is tied to a fuel pump setting and to a selected boost pressure. A servo piston adjusts the infinitely variable gear according to boost required. Any selected rpm, fuel flow, and boost pressure can thus be maintained constant with increasing altitude until maximum allowable compressor-turbine rpm is reached. Above this point a re-setting mechanism reduces fuel flow in sympathy with decreasing boost.

Paper on which this abridgment is based is available in multilithographed form from SAE Special Publications Department, 29 West 39 St., New York 18. Price: 35¢ to members, and 60¢ to nonmembers.

Multigrade Lubes

The accompanying article is based on four papers:

The New Look in Lubricating Oils
—J. B. Bidwell and R. K. Williams,
Research Laboratories Division,
General Motors Corp.

A Few Technical Problems Introduced by the New Trend in Motor Oils
—C. W. Georgi,
Quaker State Oil Refining Corp.

Multigrade Crankcase Lubricants
—J. A. Miller and L. M. Hartmann,
California Research Corp.

Fuel Economy with Multigrade Oils
—C. C. Moore, W. L. Kent, W. P. Lakin, and R. W. Mattson,
Union Oil Co. of Calif.

These papers were presented as part of the Symposium on New Developments in Crankcase Oils held at the SAE Summer Meeting, Atlantic City, June 6, 1954. Individual papers are available in multilithographed form. They can be obtained from SAE Special Publications Department at 35¢ each copy to members and 60¢ each copy to nonmembers. The Bidwell-Williams paper will be published in full in the 1955 SAE Transactions.

THREE companies, two oil manufacturers and one maker of cars, recently sized up multigrade lubricants on one or more counts. None of the three came up with exactly the same answers as the others. But, in general, their tests did indicate that multigrade lubes offer:

- **Very real gasoline economies** during the first miles of operation from a cold start.

- **At least as good antiwear characteristics** as a heavy-duty reference oil containing better-than-minimum MIL-0-2104 level of compounding.

- **Less combustion-chamber deposits (and octane-requirement increase)** than a conventional SAE 20-20W oil containing bright stock. Intake-valve deposits, however, were found to be heavier.

All Three Get Gas Savings on Short Hops

All three companies found that multigrade oils could improve the fuel economy of cars driven short distances at a time. They likewise observed that as the length of trips went up, gas savings went down.

The reason given for this is that multigrade oils reduce engine friction during the warmup period. (See Fig. 1.) On short hops, when an engine isn't fully warmed up, this results in better fuel economy. By the same token, on longer trips, when an engine is fully warmed up, gas savings don't figure to be anywhere near as big.

Keeping these facts in mind, let's take a look at the results each company got when it conducted fuel economy tests with multigrade lubes.

Union Oil road tests showed that gas savings of 5 to 10% could be expected for typical passenger-car driving at moderate ambient temperatures. Larger savings were indicated for very short trip driving or driving at low ambient temperatures. Gasoline savings appeared to have a minimum value of about 3%, even for very long trips with fully warmed-up engines.

Score High in Tests

. . . They didn't get the same marks in similar exams conducted by different companies, it's true. But, in general, they got a pretty good report card on these four subjects:

(1) fuel economy,

(2) wear,

(3) deposit-forming tendencies, and

(4) octane-requirement increase

This test work was carried out in two cars; one (Car A) was a large 8-cyl vehicle, the other (Car B) was a smaller, lighter, 6-cyl passenger car. Both cars were operated in a fashion designed to stimulate driving under moderately congested urban traffic conditions. (The operating conditions duplicated, insofar as possible, the driving which would be expected for the majority of American passenger cars.)

The cars were equipped with a series of calibrated fuel tanks so that gasoline consumption could be measured at several intervals during the course of the trip. This made it possible to determine the gasoline consumption for 1-mile trips, 2-mile trips, 4-mile trips, 6-mile trips, and so on.

To get data over a wide range of oil viscosity, four specially selected test oils were used: 5W-20, 10W-30, SAE 20 (V.I.-53), and SAE 30 (V.I.-53).

Fig. 2 shows the gasoline savings that 5W-20 gave (over SAE 20) when it was used in the large passenger car at two ambient temperatures, 50 F and 70 F.

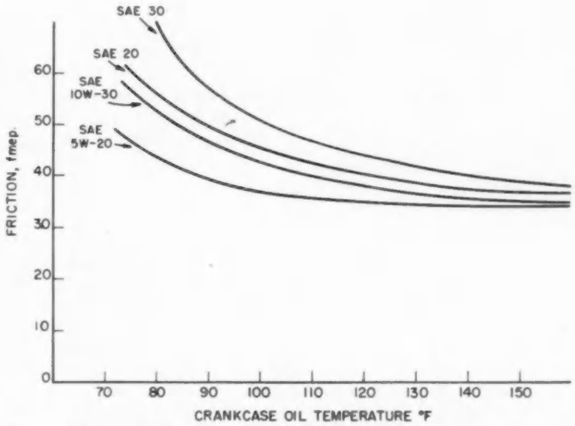


Fig. 1—One advantage of multigrade oils is that they reduce engine friction during warmup. For example, this chart shows that at about 100 F, engine friction is 20% lower with the 5W-20 oil than with the conventional SAE 20 grade

Table 1—Gasoline Savings with 5W-20 Oil Compared with Conventional SAE 20 Oil in an 8-cyl Car

	Gasoline Saved, %		
	2-Mile Trip	4-Mile Trip	6-Mile Trip
Starting temperature, 50 F	10.1	6.0	4.9
Starting temperature, 70 F	4.6	3.3	3.1

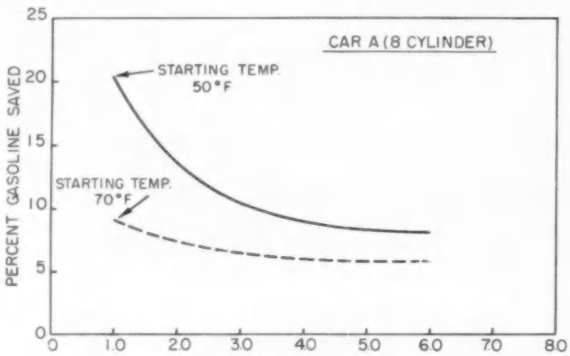


Fig. 2—This chart shows the fuel savings using SAE 5W-20 oil compared with a medium V.I. SAE 20 oil

At 50 F, these savings ranged from 8 to 13%, depending upon the length of the trip. At 70 F, they were somewhat smaller (6 to 7%), but still noteworthy.

Of course, if a more conventional high-V.I. SAE 20 oil were used in this comparison, gasoline savings would have been smaller. At a starting temperature of 50 F, for example, the savings ranged from 5 to 10%. (See Table 1.)

Still more data regarding the effect of initial oil viscosity on fuel economy of the 8-cyl engine are shown in Fig. 3. Here the gas savings obtained with 5W-20 and 10W-30 are related to the medium-V.I. SAE 20 oil. As can be seen, the 10W-30 oil provided definite savings, but these savings were only half those obtained with the 5W-20.

For ambient temperatures in the range from 50 to 70 F, the 10W-30 oil would be expected to provide substantially the same economy as conventional SAE 20. However, at lower starting temperatures, the 10W-30 would undoubtedly have a significant advantage over conventional SAE 20.

Fig. 4 shows the gasoline savings that 5W-20 gave (over medium-V.I. and conventional SAE 20 oils) when used in the 6-cyl car in an ambient of 50 F. Here again, the savings were substantial in each case.

As can be seen in Fig. 5, the 10W-30 gave an even greater advantage over the SAE 30 oils as the 5W-20 did over the SAE 20's.

Case Less Clear on Wear

On the question of engine wear, the researchers came in with a split verdict. California Research found no wear penalty from using the multigrade oils. General Motors investigators came up with evidence on cam and lifter wear that gives the new oils a somewhat less clean bill of health.

California Research investigated wear characteristics of the 10W-30 oil in the laboratory and on the road. Both radioactive ring wear test techniques and direct measurements were used. In all the tests, antiwear characteristics of the 10W-30 oil were found to be equal to, or better than, those of the reference oil—a heavy-duty oil with better-than-minimum MIL-0-2104 level of compounding and with a long history of excellent field performance.

For example, wear with the 10W-30 was compared to that of the reference oil in the SAE 10W, 30, and 40 grades in a passenger car equipped with a radioactive piston ring. Under city traffic driving, no significant difference in wear was observed with any of the oils tested.

In highway operation, the wear observed with the

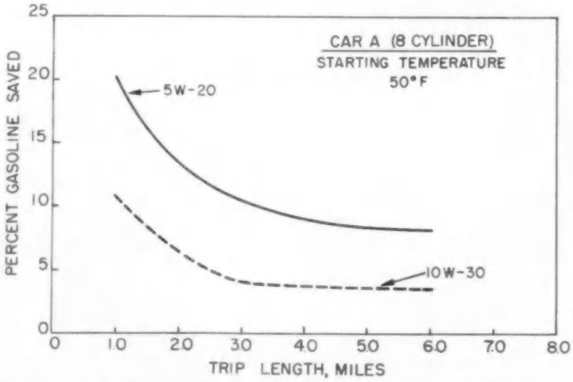


Fig. 3—Multigrade oils (5W-20 and 10W-30) showed improved fuel economy over SAE 20 oil

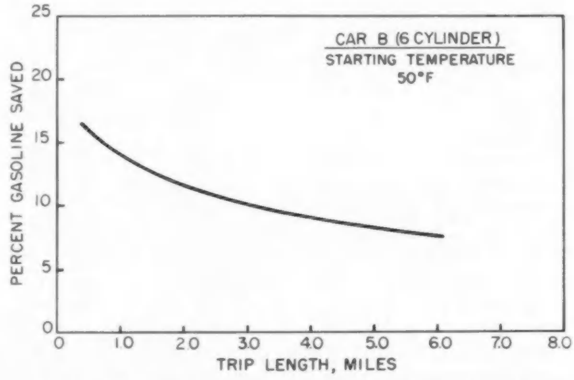


Fig. 4—As in the case with the 8-cyl car tests, the 6-cyl car investigation showed a gain in fuel economy for the multigrade oil over the conventional oil to the extent shown in this chart

10W-30 oil was slightly less than that observed with the SAE 30 reference oil. The 10W and 40 grade reference oils were not investigated in this highway cycle.

For further wear study, the 10W-30 oil was compared with the reference oil in a taxicab fleet. After 30,000 miles, physical measurements showed wear on all engine parts to be essentially the same with both oils.

GMC's Research Laboratories Division ran cam and lifter wear tests in two engine designs with three metallurgical combinations. They found that none of the new multigrade oils they tested was quite satisfactory.

The test results are shown in Tables 2 and 3. Both the LS-5 and LS-6 tests were run in a 6-cyl, valve-in-head engine (the LS-5 in the 1953 model, the LS-6 in the 1954 model). The ORI-1 was run in a 1953 model V-8, valve-in-head engine. In the LS-5 test, chilled iron valve lifters were run with a forged steel camshaft. The LS-6 test was run with six carburized steel lifters and six hardened alloy iron lifters operating on a hardened alloy iron camshaft. Carburized steel lifters and a hardened alloy iron cam are used in the ORI-1 test.

None of the oils in Table 2 gives a satisfactory LS-5 test. With the excessive wear shown, considerable scatter may be expected. But the results do check qualitatively those obtained with individual additive components.

The trends indicated in the LS-5 tests also are evident in the LS-6 and ORI-1 results. Note the high wear with steel lifters and the cams on which they operate when they are run with oils H and F. These are the oils which contain no zinc dithiophosphate. The result applies to both the ORI-1 and the LS-6 test, although the engine designs and loads differed. There was excessive wear with some of the other oils in the LS-6 tests.

While alloy iron lifters and cams seem to solve the valve gear wear problem, the wear shown with other metallurgy combinations in these tests is analogous to wear of other critical engine parts. So to provide wear protection for these other engine parts, lubricant wear-preventive properties also should satisfy the needs of steel and chilled iron lifters in these tests.

The results in Table 3 were gotten with conven-

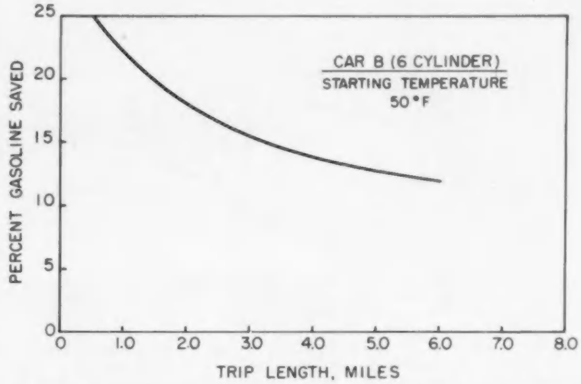


Fig. 5—The 10W-30 oil offers about the same fuel advantage over the SAE 30 oils as the 5W-20 oil has over the SAE 20 oils

Table 2—Cam and Lifter Wear Measurements with New High V.I. Oils

		LS-5 Results			LS-6 Results				ORI-1 Results	
					Steel Lifters		Alloy Iron Lifters			
Oil	SAE Grade	Pitting Severity, %	Lifter Length Loss	Cam Wear	Lifter Wear	Cam Wear	Lifter Wear	Cam Wear	Lifter Wear	Cam Wear
E	5W-20	50	10	13	44	5	7	9	3.6	5.2
A	10W-30	54	17	65	73	11	4	8	4.9	3.8
P	5W	62	26	101	81	498	4	12	—	—
B[1]	10W-30	62	18	94	78	87	8	12	3.7	4.5
C[1]	10W-30	67	28	212	124	18	7	10	21.5	7.5
Q	5W-20	74	22	90	20	6	5	6	—	—
H[2]	10W-20	75	24	96	79	157	8	9	32	56
F[2]	5W-20	92	32	206	157	318	10	10	130	144
I[1]	10W-30	100	31	161	130	22	7	12	—	—
D[1]	5W-20	100	42	340	152	22	8	13	—	—

NOTE: [1] Contains some phenol-type additive.
[2] Does not contain any zinc dithiophosphate.
(All wear values are shown in tenths of thousandths of an inch)

Table 3—Cam and Lifter Wear Measurements with Conventional Oils

		LS-5 Results			LS-6 Results				ORI-1 Results	
					Steel Lifters		Alloy Iron Lifters			
Oil	SAE Grade	Pitting Severity, %	Lifter Length Loss	Cam Wear	Lifter Wear	Cam Wear	Lifter Wear	Cam Wear	Lifter Wear	Cam Wear
E	20W	42	15	52						
S	20W	42	21	64					6	3
R[1,2]	20W	50	18	41	52	473	4	10	40	152
X	10W	75	15	89	91	90	8	9		
Z[1]	10W	100	30	100						
G[2]	20W				41	10	6	8	5.5	7

NOTE: [1] Contains some phenol-type additive.
[2] Does not contain any zinc dithiophosphate.
(All wear values are shown in tenths of thousandths of an inch)

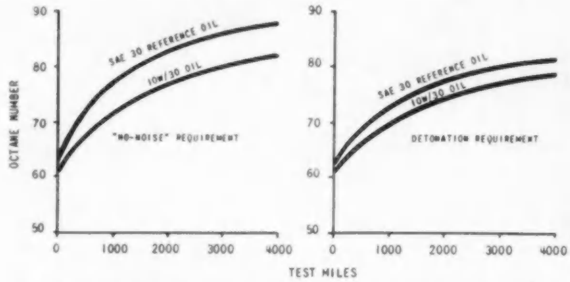


Fig. 6—Using 10W-30 oil in 30,000 miles of taxicab fleet operations showed that the multigrade oil lowered the "no-noise" and detonation requirements of the vehicles as compared with operation on SAE 30 grade oil

tional oils of high base oil viscosity and less V.I. improver than the oils in Table 2. It is apparent from the results in Table 3 that some SAE 10 and 20 oils may be as bad both with chilled iron and steel lifters as the new high V.I. products. This fact emphasizes the importance of the specific additive compound.

California Research reports that the 10W-30 oil furnished greater protection against valve train wear than a conventional heavy-duty lubricant with a highly successful service history in all type engines. These findings came from lab cycling tests on a high compression V-8 engine. The wear on the bottom of the lifter with conventional oil was 0.002 in., while with the 10W-30 oil it was only 0.0005 in., or 25% of the wear with the reference oil. Field inspection of a number of engines of various makes confirmed the laboratory test results.

Deposits and Octane Needs Lowered

California Research, in both laboratory and field experience, found that in certain cases multigrade lubes reduced octane requirement and preignition in cars operated with leaded, commercial gasoline. For example in the taxicab fleet investigation, 10W-30 oil reduced "no noise" octane need by four numbers as compared with that of other vehicles using a conventional SAE 30 oil. In these tests, the "no noise" octane requirement was the preignition requirement of the engines.

All the engines were operated with the key off when the fuel octane number was one or two numbers lower than the limiting values shown in Fig. 6. The fuel octane number to suppress detonation in these engines was four to five numbers lower than the valves to suppress preignition. The values shown in Fig. 6 are average values for five engines using each oil.

There wasn't any difference in either preignition or detonation in other engine makes and types of service with 10W-30 oil compared with SAE 30 oil. So it seems that there are conditions where 10W-30 oil helps suppress knock; in others, this benefit isn't realized.

GM researchers found both an increase in octane requirement and a drop in combustion chamber deposit weight with the multigrade oils than with conventional SAE 20-20W oil containing bright stock. These lubes resulted in exceptionally clean engines as to varnish and sludge, under dynamometer and road test conditions. But excessive quantities of light, carbonaceous deposits were observed in road tests. These deposits are considered highly undesirable since they can cause sluggish valve action, power loss, and valve burning in serious instances.

A Word of Caution

The designations given the new multiple viscosity graded oils can be misleading. Each multigrade oil is not necessarily all-inclusive as its designation might indicate, warns Carl W. Georgi. Some of them skip grades.

For instance, an SAE 10W-30 type oil can meet the SAE 10W, 20W, and 30 viscosity ranges. But it cannot fit the SAE 20 requirements. So there's a question as to whether the oil is suitable where an SAE 20 grade is wanted.

In the same way, SAE 20W-30 doesn't comply with the SAE 20 range, and the SAE 20W-40 misses out on both the SAE 20 and 30 ranges.

This condition gives rise to these questions:

1. Should consideration be given to amending the present SAE Viscosity Classification with a statement along these lines: For an oil having an extrapolated viscosity at 0 F meeting one of the "W" grades, and a viscosity at 210 F meeting one of the summer grades, all viscosity requirements for all intermediate grades are waived.

2. Are the seven viscosity grades in the present SAE Classification really necessary . . . do present-day engines really need these seven grades?

Pearlitic Malleable Iron Stakes Claims to New Jobs for Castings

Carl F. Joseph, Central Foundry Division, GMC

Excerpts from paper "Pearlitic Malleable Iron—Its Properties and Expanded Uses," presented at SAE Annual Meeting, Detroit, Jan. 11, 1954.

PEARLITIC malleable iron combines the simplicity and adaptability of a casting with the strength and reliability of a forging. Because of this unique combination, applications since World War II have shown castings made of the material to be competitive with forgings, stampings, and weldments.

1. Its Properties Make Pearlitic Malleable a Standout

Pearlitic malleable iron has many properties which make it outstanding in the ferrous field. Its properties differ, depending on the amount of combined carbon in the matrix. The higher the combined carbon, the stronger, harder, and less ductile it is. Control of the amount of combined carbon offers the user of pearlitic malleable iron a wide range of mechanical properties.

In general, the machinability of pearlitic malleable iron is from 10 to 30% better than steel forgings of the same Brinell hardness. Table 1 shows the machinability rating in percent of various types of steel forgings, pearlitic malleable iron, and cast irons. These ratings have been compiled by an authority on the subject, and our experience with many manufacturers checks very closely to those shown in this table.

The comparative results are based on SAE 1112 Bessemer screw stock at 100%. In establishing these ratings, the cutting speed of the SAE 1112 is at the rate generally used in turning this metal on automatic screw machines. The rate of feed, however, is altered to that necessary to attain normal tool life and good surface finish when using a cool-

Table 1—Relative Machinability of Various Ferrous Materials

Material	Machinability Rating in per cent	Brinell Hardness
Standard Malleable Iron	120	110–145
ArmaSteel—Class B (Pearlitic Malleable)	95	163–207
ArmaSteel—Class A (Pearlitic Malleable)	80	197–241
SAE 1022	70	159–192
SAE 1112	100	179–229
SAE 1137	70	187–229
SAE 1035	65	174–217
SAE 1040	60	179–229
SAE 1045	60	179–229
SAE 5040	65	179–229
Soft Cast Iron	80	160–193
Medium Cast Iron	65	193–220
Hard Cast Iron	50	220–240

Table 2—Minimum Physical Properties of Malleable and ArmaSteel (Pearlitic Malleable Iron)

	Malleable	ArmaSteel		
		Class A	Class B	Special
Tensile Strength, psi	50,000	80,000	70,000	100,000
Yield Strength, psi	32,500	60,000	48,000	80,000
Per Cent Elongation in 2 in.	10.0	3.0	4.0	2.0
Brinell Number	156 max.	197-241	163-207	241-269
Brinell in mm	4.8 min.	3.9-4.3	4.2-4.7	3.7-3.9

ant. Then, when the other metals are tested, the feeds and speeds are varied from these basic rates to whatever rate is necessary to obtain comparable surface finish. The ratio of these rates and speeds and feeds of each tested metal, then, determines the percentage of machinability.

Good damping characteristics are exhibited in motors using a cast crankshaft where quiet operation is a factor. The material also has desirable bearing properties. In the automotive rocker arm, operating on a hardened steel shaft, the bronze bushing can be eliminated. This illustrates the excellent non-seizing properties in metal-to-metal wear.

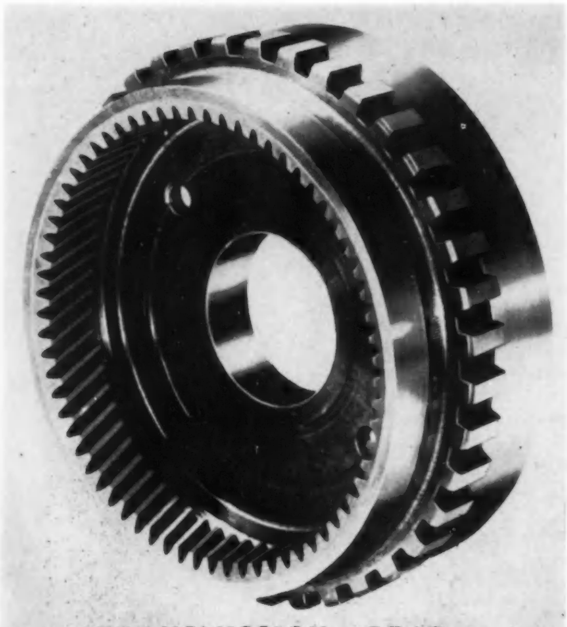
Fine machine finish is another plus value. Pearlitic malleable iron produces a mirror-like finish on parts requiring a fine finish. The material also has good strength characteristics. With a minimum yield strength of 80,000 psi and ultimate strength of 100,000 psi, pearlitic malleable iron castings can be used for many highly stressed parts.

Pearlitic malleable iron responds readily to localized hardening by either the flame hardening or induction hardening method. This operation is used on shifter yokes, crankshafts, and gears. Immersion in a lead or salt bath is used on parts which can be immersed in the hot molten bath, followed by an oil quench.

Pearlitic malleable iron provides good resistance to fatigue, giving maximum endurance and long life. It also withstands excessive wear under heavy loads at high speed. The castings are heat treated to a uniform structure and high strength.

Table 2 shows the present SAE mechanical property requirements for pearlitic malleable iron castings. It is recognized that higher tensile and higher yield strengths may be obtained from any one of the grades shown in the table by the use of a conventional quench-and-temper treatment. This increase would be accompanied by a reduction in toughness and a likely increase in hardness. Modulus of elasticity of pearlitic malleable iron ranges from 26 to 28 million.

Welding pearlitic malleable iron to steel is possible if the operation is properly carried out and the necessary precautions taken. Recently tests were completed on pearlitic malleable universal joint yokes welded to SAE 1020 CRS propeller shaft tubes. Both torque strength and fatigue life tests were satisfactory.



TRANSMISSION GEAR

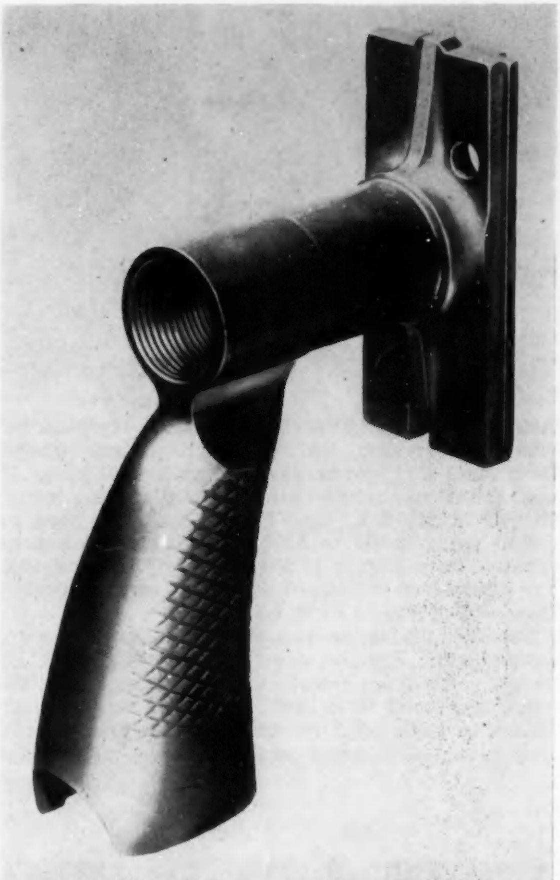
2. Material Shines in Varied Uses

Pearlitic malleable iron has worked its way into a wide variety of parts and fields. It's replacing forgings, stampings, and weldments in the automotive, refrigeration, and allied industries. Advantages of pearlitic malleable castings over other methods of fabrication are shown in the following applications:

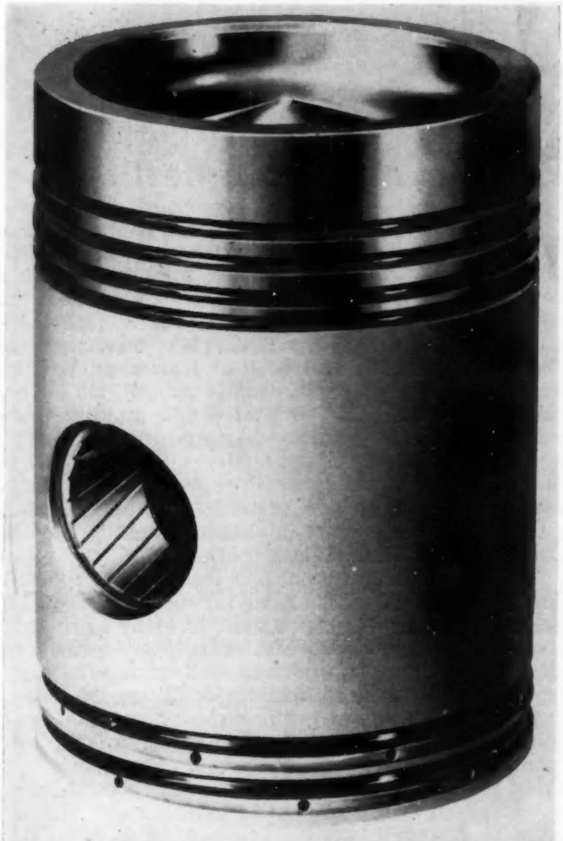
GOOD WEAR RESISTANCE: Because of its excellent wear resistance, oil quenched and tempered pearlitic malleable iron with a Brinell of 255–285 was selected to replace an SAE 5140 steel forging for this automotive reverse internal gear in the Hydra-Matic transmission. With a tensile strength of 100,000 psi and a yield strength of 80,000 psi, this pearlitic malleable iron part is rugged and durable, giving long and dependable service.

CONSOLIDATING CASTINGS: The grip, stock and back plate for the .30 caliber machine gun was formerly a three-part assembly requiring six fastening devices. The grip was an aluminum casting; the stock was machined from steel tubing; and the back plate was a forging. Now, the entire assembly is cast in a one-piece part in pearlitic malleable iron. As an integral casting, costly machining and threading operations are unnecesarry; fastening devices have been eliminated; and fewer parts must be carried in inventory.

One pearlitic malleable iron part often can replace an assembly of several parts. That's because of the many desirable characteristics of the material and the versatility of casting practice. As in the case of the machine gun part, such a component eliminates many machining and assembly operations. Very often this produces better alignment, the part is more compact, and there is no vibration on a moving part.



MACHINE GUN PART

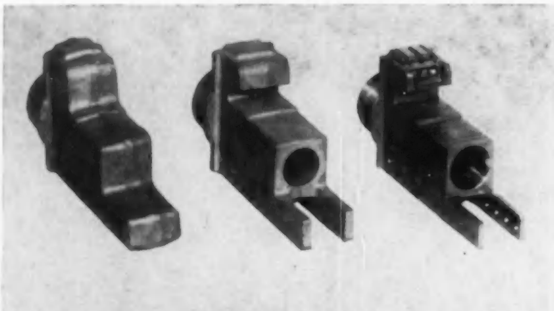


DIESEL PISTON

EXCELLENT FINISHING QUALITY: A casting with excellent finishing qualities and high strength characteristics, pearlitic malleable iron makes an ideal material for heavy-duty diesel pistons. One is shown at the left. The metal can be machined to a very smooth surface and polished to a mirror-like finish, reducing friction and wear to a minimum.

This property was readily apparent in the manufacture of .30 caliber and .50 caliber Browning machine guns. There were 16 pearlitic malleable iron parts used on the .30 caliber and 28 parts on the .50 caliber machine gun. The .30 caliber was supplied by five manufacturers and the .50 caliber by seven manufacturers, all using pearlitic malleable iron parts.

The parts were assembled and 1000 to 10,000 round firing tests made. The guns were torn down, the parts mixed up, reassembled, and again fired. The interchangeability of the pearlitic malleable iron machined parts was the one thing that amazed the Ordnance people. It was far better than steel forged machine parts. The answer to all this was the excellent finishing qualities of pearlitic malleable iron.

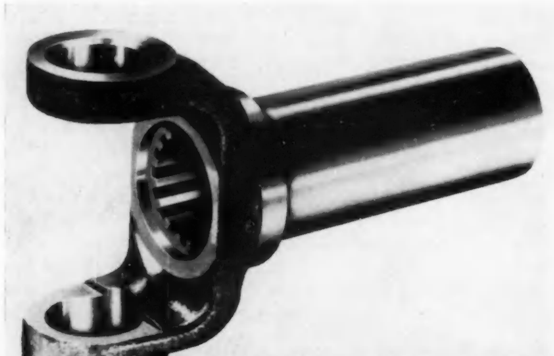

TRUNNION BLOCK
FORGING ROUGH CASTING MACHINED CASTING

REDUCED MACHINING TIME: This part, a trunnion block for a .50-caliber machine gun, was formerly machined from a 20-lb SAE 1035 steel forging. It weighs 6 lb when ready for assembly. The casting weighs 9.9 lb. Thirty-five per cent less machining time was required to machine this casting as compared to the forging.

Up to 50% in man hours of machining time is being saved where pearlitic malleable iron castings have supplanted steel forgings. Tool life is substantially increased due to easier machinability and the reduction of excess finish stock.

HIGH YIELD STRENGTH: For highly-stressed universal joint yokes, one manufacturer has changed from steel forgings to pearlitic malleable iron. He uses an oil quenched and tempered casting with a Brinell of 241–269. The broach load has been reduced from 11,000 to 5500 lb; broach life has increased from 3000 to 15,000–20,000 pieces; and average number of pieces per tool grind has been upped from 500 or 600 to from 1600 to 1800.

Pearlitic malleable iron for yokes shows up other advantages. Splines are smoother and more accurate. In drilling and reaming cross holes, tool life is improved 50 to 300% over steel forgings. It's easier to hold required tolerance in grinding the shank, and 60% fewer wheel dressings are needed.


UNIVERSAL JOINT YOKE

3. Metallurgical Control Key to Pearlitic Malleable Castings

Generally speaking, the production of pearlitic malleable iron castings is carried out in much the same manner as is the manufacture of malleable iron castings. The major difference is in the heat treatment cycle of the white iron.

The base metal used is generally of the same chemical composition as that of a regular malleable iron casting. However, some manufacturers make additions of manganese, copper manganese, molybdenum, and other elements. The purpose of these additions is to control or regulate the graphitizing rate during second stage graphitization.

The melting processes used in the production of pearlitic malleable iron castings, in most cases, are carried out in an air furnace, cupola-air furnace, or cupola-electric furnace. The cupola is used as the primary melting unit and the air furnace or electric furnace as a holding and superheating furnace. In the production of ArmaSteel, we use the cupola-electric method.

The heat treating cycle in the production of pearlitic malleable iron, in most cases, is different from that used for malleable iron. The matrix in a malleable iron casting is completely annealed, resulting in a structure of ferrite and temper carbon. Some manufacturers reheat regular malleable iron to above the critical, liquid quench, and temper. Where alloys are added to the base metal, the regular malleable annealing cycle can be used.

In producing ArmaSteel castings, the product is originally cast white, . . . all carbon is in the combined state. The castings are then heated to a temperature of 1700 F or higher to eliminate the massive carbide or cementite. This is called the first stage of graphitization. We interrupt the malleablizing cycle at 1650 F and air quench. The second stage of graphitization is carried out so that the graphitization is terminated at a point to allow sufficient combined carbon to remain in the casting to definitely affect the properties of the iron. We do this by reheating the casting below the critical and tempering back to the desired hardness. Certain castings which require higher physical properties are oil quenched and tempered.

In manufacturing pearlitic malleable iron castings, all raw materials are under rigid metallurgical control. All melting and heat treating operations are closely supervised. Most plants use some form of quality control to produce a uniform quality product. In every case uniformity of the metal poured into the casting is of prime importance. Malleable iron is a product which has been used many years, and the "know-how" of making a consistently uniform product day after day is now well established.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Preventive Maintenance Hows and Whys

R. A. Harvey, Thompson Products, Inc.

Based on secretary's report of Preventive Maintenance of Plant Equipment Panel held as part of the Production Forum at the SAE National Production Meeting, Chicago, March 29, 1954.

ADVANTAGES of a good preventive maintenance program add up to an impressive reason why no company should be without one.

Correctly set up, such a program will:

1. Lower maintenance labor costs through decreased breakdown maintenance.
2. Reduce maintenance inventory through predetermination of repairs required.
3. Decrease maintenance variable by use of standards and cost control.
4. Improve control of capital investments through relating maintenance costs to depreciation.
5. Lengthen useful life of plant equipment.
6. Increase time in production.
7. Improve housekeeping.
8. Help detect poor machine design or repeated overloading of equipment.
9. Simplify accounting procedures.
10. Cut down adjustments and attempted repairs when they might not be good practice.
11. Keep maintenance men in closer touch with equipment so that they gain experience.

How to Start

A preventive maintenance program starts with study of past maintenance costs and cost of breakdown maintenance on all current equipment. Then a procedure is established for gradual conversion of maintenance men from breakdown to preventive maintenance. This eliminates need for additional new men to start the program. New equipment added during the conversion should become part of the program.

What It Costs

Is preventive maintenance too costly? No, definitely, most experienced operators agree. Every type of industry can afford it, and most companies that have undertaken it seriously have shown savings.

One firm reduced cost per maintenance-and-material-labor hour from 35¢ to just under 30¢ in four years—a reduction of 15%. Another cut costs 20% in three years. In general, a 10% cost reduction is considered realistic.

How to Sell It

Management won't buy intangibles, and doesn't have to. So, preventive maintenance must be sold on a dollar basis, with a projected savings in maintenance labor and material. Most experts agree 70% of maintenance labor can be time studied when a preventive maintenance program is in effect. This helps reduce the variables. As the program progresses, management will become aware of other savings from increased time in production, better machine conditions, and improved attitude of production people toward their machinery.

How to Control It

Control methods depend on the kind of equipment and the size of the plant. Usually the plant engineer or maintenance superintendent is responsible for administration. He will get help from industrial engineering on standards, from accounting

> ### Who Contributed PM Data
>
> **Panel members discussing the preventive maintenance problems reported in this article were:**
>
> **W. J. Collier,** Panel Leader
> Thompson Products, Inc.
>
> **R. A. Harvey,** Panel Secretary
> Thompson Products, Inc.
>
> **Arthur Keetch**
> Warner-Swasey Co.
>
> **O. A. Teachworth**
> Pontiac Motor Division, GMC
>
> **William Allen**
> Plymouth Division, Chrysler Corp.
>
> **Leo Milan**
> Douglas Aircraft Co., Inc.

for past and current machine costs, and from manufacturing to correlate the program.

Important points for control in any preventive maintenance program are:

- Finding out whether breakdown maintenance exceeds the straight-line amortization or retirement of the equipment. Many companies use the Machinery and Applied Products Institute's formula of equipment replacement.

- Scheduling equipment and determining frequencies of operation—one of the most difficult phases of the program. One method of checking against cost is to determine average maintenance hours per year for the equipment, with an assumed percentage of breakdown. This gives a guide for estimating savings from the breakeven point. To check against frequency, watch breakdown maintenance and establish accurate records for each piece of machinery.

Some companies use hour meters to determine running time of machines. Others rely on historical background and general usage of machine types. Some schedule and keep records with Addressograph, Kardex, and checklists; others use IBM equipment for schedules, costs, and records.

- Keeping management and manufacturing informed of excessive costs of maintaining obsolete, badly designed or abused equipment and machinery.

(The report on which this article is based is available in full in multilithographed form together with reports of other panel sessions of the Production Forum held at the SAE National Production Meeting, March 29, 1954. This publication, SP-306, is available from the SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.)

Glamor Goes Scientific . . .

. . . under spur of chemical developments. Bright new colors, better finishes, and synthetic fabrics in endless array, provide field day for stylists. And this is only the beginning.

Based on paper by **S. L. Terry,** Chrysler Corp.

ONLY recently have stylists begun to probe the real potential of color and texture to enhance the intrinsic beauty of automobile styling. We may properly call it "glamorizing," but rather the aim has been to bring new dimension, freshness, force and appeal through color and texture that reinforce without dominating, accent without overemphasizing, and unify without subduing the elements of design.

Some people ask how far we can go with new colors. This can be answered positively by measuring colors in terms of wave length and intensity with a colorimeter and from this plotting a chromaticity diagram. Because color is dependent on light, the colors of the spectrum represent the highest chromaticities, or purest colors possible. Thus, the colors of the spectrum form the boundaries of the curved portion of the chromaticity diagram. By locating the actually available colors on this diagram, we can see just how far present-day pigments have approached their limit.

Red, yellow, and orange pigments are available

which give close to the maximum possible chromaticity. However, blue, green, and violet pigments are only a little more than one-third the purity which is theoretically possible. So the science of color tells us that the development of new pigments in the future should bring enormous increases in the intensity of blues and greens.

One might wonder how colors for paint and fabrics are chosen for automobiles, where mismatches are intolerable. The Macbeth Skylight has been developed for this purpose and serves as a standard. This lamp simulates light from the north sky and from the evening sun. When two colors harmonize under both these conditions, we can be assured they will look well under nearly all lighting conditions. The lamp also serves to control color in production. Since paints and fabrics from different suppliers may all be used together in one car, it is essential that their colors be as consistent as possible. Therefore, samples are compared with master samples under the Macbeth lamp.

Data accumulated in the fields of furniture, household paint, clothing, and others, indicate that color preferences are cyclical in nature. Bright red, for example, may be used for 20% of the upholstery fabrics sold in a peak year. Then it gradually drops to a minimum of 5% of the total 10 years later. It can be predicted that in another 10 years red will be back again near the 20% figure.

Color cycles have not been established for automobiles because of the relatively short period in which a representative color range has been available. Nevertheless, a cyclical trend in the use of bright colors followed by a period of grayed down colors is evident. We are in the middle of a high chroma, light value, "clean" color era; grayed, subdued tones will inevitably follow in popularity.

The color and texture effects made possible by synthetic fibers have opened new opportunities to the stylist. Instead of picking fabrics from eight or ten basic cloth constructions, there are literally thousands to choose from, and new and strikingly different designs are being developed every day.

The synthetic fabrics have revealed new frontiers in the use of color. By using different fibers and fiber blends in weaving the pattern, and dyeing the fabric after it is woven (cross-dyeing), two and three color pattern effects can be achieved. This is made possible by the varying affinity the various fibers have for a particular dye. A given dye formula, for example, may color viscose dark blue, nylon light blue, and leave acetate white. Cross-dyeing is widely used because it gives a flexibility to scheduling. Three or four colors of a given body cloth can be made from the same goods, thus, the automobile manufacturer can commit for a large yardage and change the color of the goods after they are woven, in accordance with changes in public demand. (Paper "The Science of Glamor" was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 2, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Based on oral discussion

A. S. Olver, Imperial Oil, Ltd.: What about static electricity condition caused by synthetic fabrics?

Mr. Terry: Probably the worst offender is Saran Plastic. Many people associate the static electricity of Saran with other synthetics because of experience with Saran seat covers. This is not a good comparison because Saran is more often used for seat covers, not as original upholstery fabric. Present day synthetics, usually a blend of several synthetics and wool or cotton are not too objectionable in this respect. This is a problem. As yet we know of no way to make synthetics as static-free as pure wool.

W. Delbridge, Woodall Industries, Inc.: Do you think the public definitely likes the "feel" of synthetics and vinyls over that of cloth and leather?

Mr. Terry: No. We don't believe the public will ever give up the "feel" of a good wool cloth. They are becoming more and more conscious of the benefits offered by vinyls and synthetics. Wool has certain characteristics which make it desirable by itself and in blends with synthetics. Wool may appear in the future in a new blend of wools which will have all the characteristics of wool plus the lustre, sheen, and strength of some of the synthetics.

C. J. Van Haltern, Chrysler Corp.: How does the use of more color, brighter and higher chroma colors affect the fading characteristics?

Mr. Terry: Dark fabrics are usually more susceptible to fading than the lighter fabrics. However, some of the new, bright synthetics are not without their problems of fading and dye stability. A fabric which has good dye stability does not always have good fade resistance. Therefore, manufacturers are forced to compromise between dye stability and fade to get a satisfactory combination of both.

Wm. Harrington, General Motors Corp.: Two things establish beauty, color and form. Does your emphasis on color and fabrics mean that you are neglecting form?

Mr. Terry: Certainly not. Exterior design is still, and always will be, of prime importance. Interior treatment has been raised to a position of equal importance with exterior design.

L. L. Anderson, Chrysler Corp.: Heat-asbsorbing glass tends to destroy good color harmony in certain instances. Is there a solution?

Mr. Terry: This is a compromise problem. Heat-absorbing glass has definite merit which cannot be overlooked merely for the sake of color harmony. One answer to the problem in our case of Solex glass, which has a greenish cast, would be to use more green combinations.

LPG Engines Are Now

THE success of field-converted LPG engines has led several manufacturers to offer some of their engines equipped at the factory to burn LPG.

Two of these engines—the International Harvester RD-450 and the Reo OA-331—Will be described here.

International Harvester Engine

The results of dynamometer tests and reports of customers indicate that the performance of this engine compares favorably with that of gasoline-fueled engines. To attain this goal, however, a higher compression ratio had to be used.

The RD-450 gasoline engine has a piston displacement of 75.165 cu in., and at sea level the total volume is 89.568 cu in. The compression ratio is 6.21/1 with standard pistons. Using 5000-ft pistons, the total volume is 87.593 cu in. and the compression ratio is 7.04/1. Using 10,000-ft pistons the total volume is 86.253 cu in. and the compression ratio is 7.7/1. Experimentation with compression ratios as high as 9.1/1 indicated that the RD-450 engine with 10,000-ft pistons and a compression ratio of 7.76/1 would give best results.

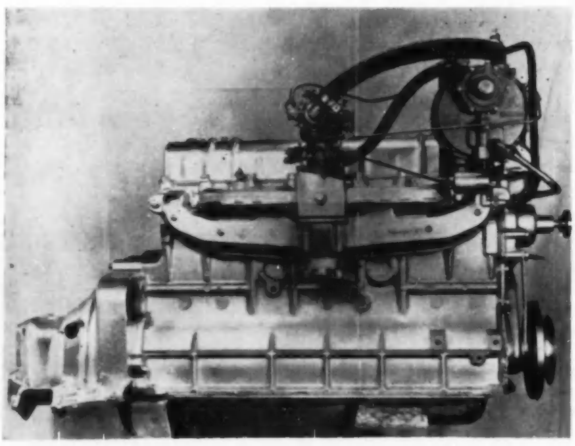


Fig. 1—International engine designed at factory for LPG

Fig. 1 shows an International engine designed at the factory for LPG. This engine has 10,000-ft pistons and there has been a change in the center section of the exhaust manifold to eliminate hot spots. The Ensign fuel system is used and in the illustration may be seen the fuel filter, the regulator, and the carburetor.

Fig. 2 compares the performance of the RD-450 engine using propane and gasoline. As will be noted, the engine when operated on propane had a 7.76/1 compression ratio and while operated on gasoline had a 6.3/1 compression ratio. With the engine changes designed to enable the engine to operate on LPG it is believed that the chart shows that performance from the standpoint of torque and power are roughly equal to one another. Actually, the peak torque occurs some 300 to 400 rpm sooner with LPG. The horsepower curves are practically identical. From the test work represented by this chart there was an approximate 35 F–40 F temperature rise over inlet air temperature, which is comparable with the rise on standard gasoline manifolds. In dynamometer tests there was no indication of difficulty on idle or progressive operation with propane equipment. Specific fuel consumption was somewhat higher on LPG, particularly in the lower range of engine rpm, but tended to approach that of gasoline in the higher ranges.

Fig. 3 shows in more detail comparative fuel consumption on this engine between LPG and gasoline. The specific fuel consumption curves are inserted from the previous chart. Fuel consumption in gallons per brake horsepower per hour is a conversion from the pounds per brake horsepower per hour and indicates the same trend. However, although the

Being Factory-Designed

E. A. Jamison and William A. Howe, Gulf Oil Corp.

Excerpts from paper, "Conversion and/or Design of Automotive Engines for LPG," presented at a meeting of the Metropolitan Section of the SAE, New York City, Jan. 20, 1954.

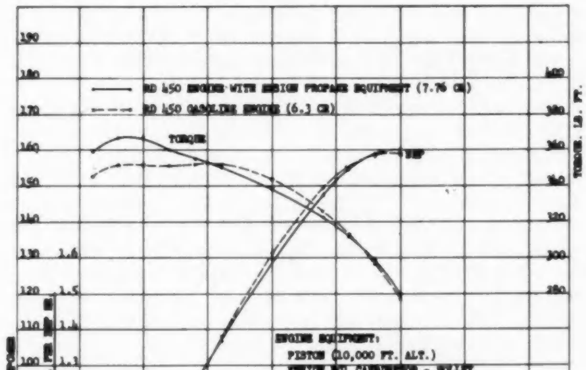


Fig. 2—Comparative performance for International RD-450 engine using propane and gasoline

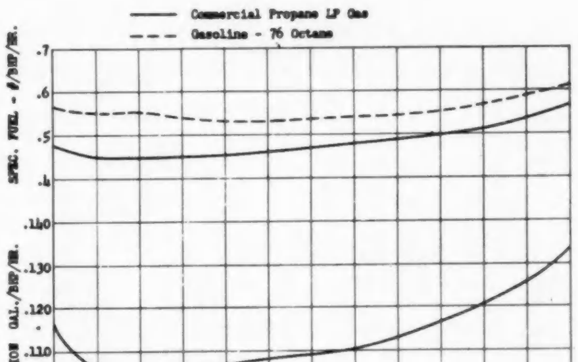


Fig. 3—Comparative fuel consumption for International RD-450 engine with Ensign propane equipment

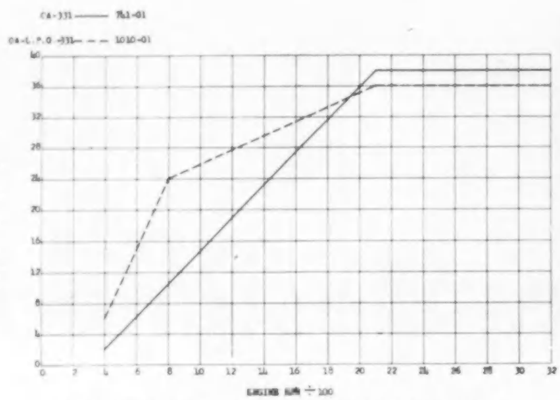


Fig. 4—Engine distributor curves for Reo OA-331 engine

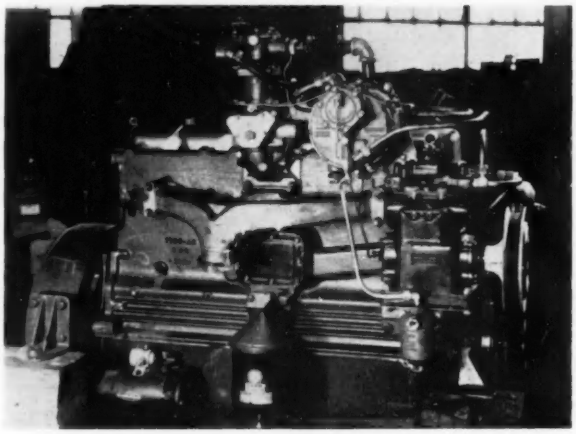


Fig. 5—Reo OA-331 engine equipped with Ensign LPG fuel system

lower set of curves showing fuel consumption in gallons per hour is another way of expressing the same information as the other two curves, it is perhaps more understandable to the automotive man. Incidentally, these curves were run at full load and, as can be seen, the comparative fuel consumption between LPG and gasoline is very similar, with a slight edge in favor of gasoline on these dynamometer tests.

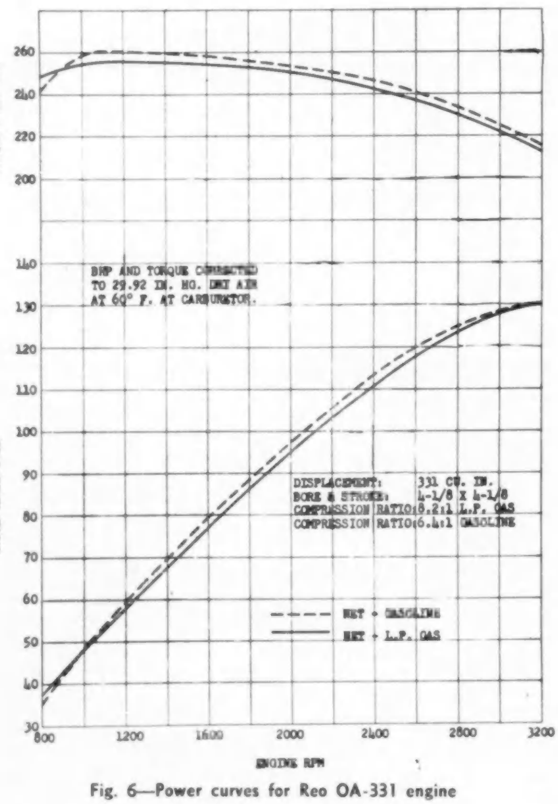


Fig. 6—Power curves for Reo OA-331 engine

Reo Engine

Reo Motors started with their OA-331 cu in. displacement engine, increasing the compression ratio from 6.4/1 to 8.2/1. They have put in hard-faced intake valve seats and hard-metal intake valves. The use of hard-metal valves in the intake has generally been found to be advantageous because a gaseous fuel can contribute little to valve cooling as compared to a liquid fuel like gasoline. Therefore, particularly when the compression ratio has been raised, it appears advantageous to change the intake valve setup to give somewhat more heat-resistance properties. The Ensign fuel system is being used.

One very interesting feature which the Reo people have put on their LPG engine is a distributor of special design for operation on this type of fuel. Fig. 4 shows distributor curves for gasoline and LPG. As can be observed, the curve for LPG has two rates of advance, shifting at 800 rpm and leveling off at approximately 2050 rpm—the same point at which the gasoline distributor levels off. This special distributor is designed with two sets of weights, one set being fixed to slow the rate of advance at 800 rpm, while the second set continues the rate of advance up to 2050 rpm. To the best of the authors' knowledge, this is the only instance where a special distributor is used for LPG. Fig. 5 shows the Reo OA-331 LPG engine equipped with the Ensign fuel system. Fig. 6 shows torque curves and brake horsepower curves for the OA-331 engine on gasoline with a 6.4/1 compression ratio and on propane with an 8.2/1 compression ratio. As can be seen, there is a slight advantage for propane on torque below 900 rpm. From that point on the torque for both gasoline and LPG follow one another very closely. With regard to brake horsepower, the net brake horsepower for both gasoline and LPG follow each other very closely, except that the initial horsepower below 850 rpm is slightly in favor of propane.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

15 Paths to Better Factory Cost Control

New kinds of standards continue to develop as a help to factory cost control. And controls are resting ever more heavily for their effectiveness on the many standards already in use. Other specific aids to practical cost control are being suggested too. But when the experts swapped ideas at the SAE Aeronautical Production Forum last Spring, use of standards —new or old—was dominant in almost half the specific ideas developed.

F. W. Prentiss, Fairchild Engine Division, Fairchild Engine and Airplane Corp.

Based on secretary's report of Panel on Factory Cost Control held as part of the SAE Aeronautic Production Forum, New York, April 12, 1954.

Six Ways Standards Can Help . . .

1. The most efficient basis for controlling manpower is to set estimates of times (standards) within which each productive operation should be completed. "Rule-of-thumb" ratios too easily can go awry with changes in production level or other elements in the "ratio."

2. Standards might even be set effectively on heat-treating, anodizing and similar operations—although such charges now usually go to overhead because they are hard to segregate.

One suggestion: Set standards for such operations on a per square inch basis. Then accumulate actual time by taking the total plating time, for example, for all pieces and dividing by the square inches involved. Then measure this against the predetermined standard.

3. Another suggestion: Large cost savings probably can be effected by setting standards to assure proper maintenance of machines and tools. Use of such standards usually extends the usable life span of the equipment.

4. Giving foremen each day the record of each individual operator in relation to the standards set for his operation helps to control costs in some plants. One company puts such "efficiency reports" for the previous day on superintendents' and foremen's desks at 7 a.m. each morning. These supervisors use it to insist on "efficient" operations.

5. Buildup of standards for maintenance and plant engineering operations helps to control costs when combined with having maintenance workers "clock in" and "clock out" on their various assigned jobs.

6. On one thing, all the experts seem to agree as regards getting the best use of standards for cost control:

Unless major changes are made in an operation, standards should not be changed more than once a year; certainly not more than twice a year.

Please turn page

The men from whom came most of the 13 suggestions detailed in the accompanying article were members of this Panel on Factory Cost Control:

F. H. Wittmer, Panel Leader
Fairchild Engine Division
Fairchild Engine & Airplane Corp.

F. W. Prentiss, Panel Secretary
Fairchild Engine Division
Fairchild Engine & Airplane Corp.

Herbert Stelljes
Curtiss-Wright Corp.

E. H. Martin
Aircraft Gas Turbine Division
General Electric Co.

Alexis Von Goertz
Republic Aviation Corp.

J. S. Allt
Leece-Neville Co.

P. G. Lewert
Sperry Gyroscope Co.

Four "Musts" for Purchasing Department . . .

. . . according to men responsible for controlling costs, are:

- Three bids should be obtained wherever possible;
- When feasible, large volume buying on long-term delivery schedules should be attempted to reduce prices;
- At least two vendors should be utilized to supply each part and raw material desired;
- Have a controller's office approval to formalize a "Request for Purchase" into a "Purchase Order."

  Purpose: automatic control over wasteful procurement.

Five More Suggestions for Better Cost Control . . .

1. Send technicians to subcontract plants to schedule operations and suggest more efficient methods.

2. Look into the possibilities of either "tear tickets" or "job clocks" in connection with the Route Sheet which in most plants accompanies material as it goes through various production steps. Here is how each of these Route Sheet variations is working in one or more plants.

The Tear Ticket: The Route Sheet bears "tear tickets" which can be removed when an operation is completed. On them can be entered the time of the operation and the number of pieces concerned. The timekeeping department accumulates these data and passes them on to the cost department for its use.

The Job Clock: Use the Route Sheet only as an instruction to the operators. Collect the time by a job clock. . . . When the operator gets the Route Sheet, he presents it to the timekeeper. The latter enters the proper charge from the Route Sheet to the job card. He hands the job card to the operator, who "punches in" on the job clock. When finished, he "punches out". . . . At day's end, all job cards and hours noted thereon for each operator are accumulated. The hours worked per man must equal the total hours of attendance per man—as evidenced by this attendance card which is "punched in" on arrival and "punched out" on departure. . . . This information then goes to the cost department.

3. Timestudy engineers should be "shop trained" personnel.

4. A "Value Analysis Program" can be of great help to cost controllers. Such a program involves a detailed check into every component of a product to determine (a) the essentiality of each piece and (b) minimum requirements of each piece on tensile strength, finish, and necessary manufacturing operations—without disregarding essential quality needs. Result often is elimination of parts, material finishes, or reduction of labor.

5. Before jumping into an overtime operation, ask the following questions—and consider carefully your answers:

a. Might it cost less to acquire additional equipment? If so, is adequate space available?
b. Will we be getting what we pay for—since rate of labor productivity falls sharply with excessive hours?
c. Is Saturday overtime more productive than the use of "after-shift" hours?
d. Should multiple shifts be considered rather than the use of overtime?
e. Have production schedules been properly set and coordinated to avoid overtime? Or can they be adjusted to avoid overtime and still maintain satisfactory delivery schedules?

(The Secretary's report of Panel on "Factory Cost Control" on which this article is based is available in full in multilithographed form together with the reports of six other panel sessions presented at the SAE Aeronautic Production Forum in New York, April 12, 1954 as SP-307, from the SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.)

West Coast Meeting Maps Road Ahead

In Vehicle Engineering

THE SAE National West Coast Meeting in Los Angeles was like a ballon ascent to more than 300 automotive engineers, with a panorama of ground vehicle engineering below them. For three days, Aug. 16-18, they were given a bird's eye view of progress to date in vehicle engineering and the immediate road ahead.

Dinner speaker John M. Campbell tuned in with the what-have-we-done and what-are-we-doing-theme of the Meeting in his talk on vehicle engine combustion. (Campbell is chairman of the Automobile Manufacturers Association's Vehicle Combustion Products subcommittee and associate director of GM's Research Laboratories Division.) Said Campbell, engine researchers are bringing about cleaner exhaust in their aim toward more miles per gallon. He pointed out that combustion efficiency improvements over the past 25 years already have cut exhaust emissions 33%. And a check of a representative group of cars shows that carbon monoxide has been halved since 1927.

To help alleviate the air pollution problem, Campbell's subcommittee has recommended this four-part program:

1. Initiation by CRC of a survey of motor vehicle exhaust composition.
2. Cooperation with local dealers to develop a campaign for reducing visible emissions from cars through proper maintenance.
3. Advising the industry of the loss in fuel economy represented by unburned fuel in the exhaust.
4. Continued cooperation with technical groups on atmospheric pollution from automotive equipment.

Other engine-fuel specialists at the Meeting revealed that combustion is still a little understood phenomenon. Only now are they beginning to see pinholes of light through the iron curtain of ignorance on knock. They're finding that preflame reactions before fuel combustion control knock. And tetraethyl lead, for example, doesn't affect early hydrocarbon reactions, but does slow some of the later stages of reaction.

Petroleum technologists told of their present uphill battle to improve combustion with fuel additives. They pointed out that additive development must achieve the desired improvement without bringing any penalties. Additive development is a tricky business at best.

For instance, as little as 1 gal of additive in 50,000

Pre-Dinner Briefing

Dinner Speaker J. M. Campbell (second from left) gives his views on smog to (left to right) M. E. Russell, chairman of SAE Southern California Section; Miss Pieti, automotive engineer with Chrysler Corp.; B. T. Anderson, general chairman of the Meeting; and SAE President William Littlewood.

gal of gasoline may cut exhaust valve life by 50%. Yet increased amounts of the same additive may actually increase exhaust valve life by more than half.

One thread of continuity through the where-we're-going discussions at the Meeting was the need for more and better instrumentation and test methods. Pollution studies, knock researches, and fuel and oil development all hinge on improved research tools. Fleet men echoed these sentiments on the need for better instruments in their operations. One operator decried the waste in making major overhauls at a set time or mileage. "Why not eliminate troubles just before failure?" he asked. But to conduct this kind of inspection and maintenance, operators want better instruments . . . even X-ray equipment if need be.

As a partial answer to this fleet operator came a report of an "on-the-spot" method of testing used oil. This fast method of testing oil not only tells the operator whether the oil is usable, it also gives him clues to engine troubles.

(Following are excerpts from each of the papers presented at the Meeting.)

Knock and Antiknock

There has been much dispute as to what material actually acts as the antiknock when tetraethyl lead is added to a fuel.

Evidence shows either metallic lead or lead oxide can act as an antiknock in a very finely divided form. Difficulty is in introducing these materials into an engine in small enough particle size.

Tetraethyl lead is ideal because it decomposes at just about the right time in the cycle to produce finely divided lead or lead oxide just when needed. . .

. . . **B. M. Sturgis**, E. I. duPont de Nemours & Co., Inc., "Some Concepts of Knock and Antiknock Action."

Cylinder and Ring Wear

Viscosity at high temperature is an imperfect indicator of the ability of cylinder lubricants to prevent contact wear.

Volatility, expressed as the amount of oil which will resist vaporization from a hot, thin film, is a reasonably good guide to the quality of an oil to prevent cylinder contact wear.

A linear combination of the factors of viscosity at high temperature and film evaporation gives the best agreement with the wear figures provided by the engine. . .

. . . **H. V. Nutt**, U. S. Naval Engineering Experiment Station; **E. W. Landen**, Caterpillar Tractor Co.; and **J. A. Edgar**, Shell Oil Co., "The Effect of Surface Temperature on the Wear of Diesel Engine Cylinders and Piston Rings."

Better Transmissions

Torque converters increase truck engine life and improve fuel economy.

This is because they have less engine revolutions per mile than mechanical drives, and provide a much better power factor where load variation is high.

On one long steep grade where both types operated, the mechanical unit required 19 shifts to negotiate the hill and maintain best possible speed. The converter needed one. At the top of the grade, the mechanical-drive truck

was going 10 mph, the converter-drive truck was going 30. . .
. . . **R. M. Schaefer**, Allison Division, GMC. "Transmission Developments for Trucks and Buses."

Testing Additives

Some additives tested preferred to remain somewhere in the induction system rather than follow fuel and air mixture into the combustion chamber.

It was also found that beneficial effects of an additive on surface ignition, for instance, might be nullified if another compound were added to produce satisfactory induction qualities.

One combination produced combustion chamber deposits such that the engine continued to run for long periods after ignition was off. . .
. . . **A. E. Felt**, **R. V. Kerley**, and **H. C. Sumner**, Ethyl Corp., "Fuel Additives and Engine Durability."

Simplified Fuel System

Cummins' new pressure time diesel fuel system uses a simplified injector to perform both metering and injection functions. Fuel flow from the pump is continuous so that no timing to the engine is required. It has no high pressure check valves or any other check valves.

The system is capable of operating at greatly increased engine rotative speeds, and is simple and inexpensive compared to gasoline engine carburetion and ignition systems. . .
. . . **J. W. Rowell** and **C. R. Boll**, Cummins Engine Co., Inc., "The New Cummins PT Diesel Fuel System."

Quick Oil Analysis

"On-the-spot" technique for rapid oil analysis has been sucessfully developed for used lubricating oils taken from gasoline, diesel, and gas engines.

Field use of the technique has allowed operators to control oil drains. It provides means for quick spotting of engine malperformance that markedly affects used oil condition. Plugged air cleaners, faulty injectors, faulty carburetion and coolant leaks have all been detected in this way. . .
. . . **V. A. Gates**, **R. F. Bergstorm**, **T. S. Hodgson**, and **L. A. Wendt**, Shell Oil Co., Inc., "On-the-spot" Testing of Used Lubricating Oils."

Stop Over-Maintaining!

Instead of performing major overhauls at set times or mileages, fleet operators should carry them out only when vehicles require such attention.

Ways and means must be developed for locating troubles just prior to failure. The only answer is better inspection. This means we must have better

Around the Meeting . . .

SAE President William Littlewood said in his dinner talk that transportation of the future will be a clarification of today's trends. The objective: to get more goods and people from here to where they want to be. The tools needed to achieve this will have to be engineered into an efficient, composite structure, said Littlewood. SAE integrates the engineering of these transportation tools.

President Littlewood emphasized the need for continued adherence to these SAE objectives in performing its integrating functions:

1. To be frank and honest in our approach to engineering matters.
2. To focus on high-quality technical pursuits in various SAE areas.
3. To expand the Society's product (service) and to hold high the technical quality of membership.

* * * *

R. C. Norrie, of Kenworth Motor Truck, pinch hit for D. H. Mikkelson by presenting Mikkelson's paper on fleet maintenance.

* * * *

Coast-to-coast collaboration on the authorship of the paper on diesel engine wear set some kind of a record. The authors were: H. V. Nutt, who is from Annapolis, Md.; E. W. Landen, from Peoria, Ill.; and J. A. Edgar, from Martinez, Calif.

* * * *

Mrs. Frank Elliott arranged a full docket of activities for the ladies whose husbands attended the Meeting. Included were events such as reservations to Jack Bailey's television show "Queen for a Day," a tour through Universal City motion picture studio, and a visit to Knotts Berry Farm.

* * * *

Editorial coverage of the Meeting by William E. Achor, field editor of the SAE Southern California Section, made this Journal report possible. Assisting him as technical session secretaries were: P. W. Sheehan, E. R. Jackson, J. F. Snider, J. F. Beach, R. S. Orchard, and O. H. Jacobsen.

Lining Up to Register

These earlybirds at the registration desk launched the Meeting on the opening morning

inspectors, and we must give them more and better testing equiment.

If a lot of the same type of failures occur, the inspection system needs changing. . .

. . . **David H. Mikkelson**, Los Angeles-Seattle Motor Express, Inc., **"Can a Fleet Be Over-Maintained?"**

Multi-Grade Oils

First and most obvious improvement in engine performance with multi-grade oils is ease in starting—either quicker starting at a particular temperature or starting at a much lower temperature.

Very real gasoline savings can be made with multi-grade oils. For typical passenger-car driving at moderate temperatures, fuel bills would be reduced 5 to 10%. Short-trip driving or driving at lower temperatures would bring further economy. Tests with fully warmed-up cars have shown fuel savings of 3% even on long trips. . .

. . . **C. C. Moore**, **W. L. Kent**, and **W. P. Lakin**, Union Oil Co. of Calif., "Multi-Grade Oils for Improved Performance."

Heads and Gaskets

Many operators agree that in the race for more horsepower, results have been accomplished at a sacrifice to thorough and final engineering on heads and valves and gaskets. These parts have suffered by the increased loads imposed on them.

In many instances, while it has naturally cost the operator heavily, it has also been expensive to the manufacturer.

Wouldn't it be a good time to stop and take a good look, and perhaps repair a few fences? . . .

. . . **L. E. Kassebaum**, Consolidated Freightways, Inc., **"Automotive Engine Head and Gasket Problems."**

Truck Steering

True center point steering eliminates the need for camber in that the king-pin centerline and the wheel centerline are imposed one on the other.

The age-old objection to true center point steering (need for a deeper dish wheel) has been overcome. It was a case of doing away with the conventional, non-rotating spindle.

The new axle incorporates a rotating spindle with a non-rotating pivot hub mounted in the yoke and pivoted on steel balls resting in nylon cups. . .

. . . **A. S. Page**, Page and Page Co., **"True Center Point Steering."**

Power Steering

Power-steering designers and manufacturers today can't agree on the answers to these four questions: How low should steering effort be reduced? How to obtain the greatest amount of recovery? How to put "feel" back into the steering wheel? How low an effort will effect recovery in some cases?

Another industry-wide discussion centers around the relative merits of the different types of steering. Each presents installation problems. The integral gear type sometimes sticks out in the wrong places. Linkage units present a problem of careful treatment of flexible hose location. . .

. . . **R. A. Garrison**, Garrison Mfg., Co., **"Recent Developments in Power Steering."**

At the Dinner

Highspot of the Meeting was the dinner, where J. M. Campbell talked about the relationship of engine combustion to air pollution, and SAE President William Littlewood discussed the Society's role in the future of transportation

SAE NATIONAL MEETINGS . . .

October 5-9, 1954
National Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

October 18-20, 1954
National Transportation Meeting and Truck and Bus Engineering Display
The Sheraton-Plaza
Boston, Mass.

October 26-28, 1954
National Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 4-5, 1954
National Fuels and Lubricants Meeting
The Mayo, Tulsa, Okla.

January 10-14, 1955
Golden Anniversary
Annual Meeting and Engineering Display
The Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Mich.

March 1-3, 1955
Golden Anniversary
Passenger Car, Body and Materials Meeting
The Sheraton-Cadillac Hotel, Detroit, Mich.

March 14-16, 1955
Golden Anniversary
Production Meeting and Forum
Netherland Plaza, Cincinnati, Ohio

April 18-21, 1955
Golden Anniversary Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Statler and McAlpin Hotel, New York, N. Y.

June 12-17, 1954
Golden Anniversary
Summer Meeting
Chalfonte-Haddon Hall, Atlantic City, N. J.

August 15-17, 1955
Golden Anniversary
West Coast Meeting
Hotel Multnomah, Portland, Ore.

September 12-15, 1955
Golden Anniversary
Tractor Meeting and Production Forum
Hotel Schroeder, Milwaukee, Wis.

October 11-15, 1955
Golden Anniversary
Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

Amos E. Neyhart . . .

. . . will receive the 1954 Beecroft award for his substantial contributions to traffic safety.

Amos E. Neyhart

Prof. Amos E. Neyhart of The Pennsylvania State University has been named to receive the 1954 David Beecroft Award "in recognition of a substantial contribution to the safety of traffic involving the use of motor vehicles."

This is the eighth of ten such awards to be made as a result of a bequest of $2500 to SAE in the will of the late David Beecroft who was president of the Society in 1921.

Neyhart is administrative head of Penn State's Institute of Public Safety, which—among other functions—runs the annual Motor Fleet Supervisor Training course there.

He will receive the award at the National Safety Congress on Monday afternoon, October 18 in Chicago. J. N. Bauman, chairman of the Beecroft Award committee and vice-president of the White Motor Company, will present the Award certificate and a check for the $250 which the Award entails. Then Neyhart will address the Congress on "Driver Education—The Key to Safe Operation of Motor Vehicles." A monograph containing the lecture will be added to the David Beecroft Memorial Library on Traffic Safety and made available by SAE for widespread distribution.

Neyhart is a pioneer in driver education. He presented the country's first high school driving course in the State College (Pennsylvania) High School in 1934. This was the forerunner of what developed into a nation-wide program to train high-school-age beginning drivers. At Penn State's 1936 summer session, he presented the first teacher-training course in driver education. Later he inaugurated the program for training fleet supervisors and courses for school bus driver supervisors and for military and Red Cross personnel.

The Beecroft Award Committee consists of:

J. N. Bauman, Chairman, Society of Automotive Engineers; Pyke Johnson, Automotive Safety Foundation; P. J. Monahan, Automobile Manufacturers Association; A. J. Veglia, American Association of Motor Vehicle Administrators; A. E. Johnson, American Association of State Highway Officials; H. S. Fairbank, Bureau of Public Roads; John Gleason, International Association of Chiefs of Police.

About

Creson, W. K., Retires From Ross

WILLIAM K. CRESON, vice-president of engineering for Ross Gear and Tool Co., Lafayette, Ind., for the last eleven years, has retired after thirty years' service. He will still be connected with Ross as consulting engineer on manual and power-steering of automotive vehicles, on a part-time basis.

Creson joined the Ross organization after graduation from Purdue in 1924, and was successively plant engineer, assistant chief engineer, and chief engineer, before his election as vice-president in 1943. He was chairman of SAE's Indiana Section for 1936-37, and is still serving on the SAE Truck and Bus Activity.

He expects to continue his SAE associations, where his long service in the Truck and Bus Activity, as a past-chairman of the Indiana Section, and also of the Student Committee, have given him a background of considerable experience in Society matters.

SAM TOUR, chairman of the board, general manager of Sam Tour & Co. of New York, was honored at the 57th Annual Meeting of the American Society for Testing Materials by an Award of Merit "for long and fruitful service to the Society extending over many technical fields and administrative phases, for work on test methods, and especially for contributions to the metals and corrosion fields."

GEORGE W. BROWN, executive engineer of Wagner Electric Corp., St. Louis, Mo., has been elected a vice-president by the company's board of directors. In his new capacity, Brown will now have complete charge of Wagner's Engineering and Research Divisions, both automotive and electrical. He will also serve as a member of the company's executive committee.

Brown

Schuyler

ROBERT S. SCHUYLER is now division truck manager of the West Coast Truck Division, Dodge Division, Chrysler Corp. The West Coast Truck Division of Dodge is composed of the Los Angeles, San Francisco, and Portland regions. Schuyler was formerly truck sales supervisor, operating from the San Leandro, Calif., plant.

HERMAN L. WECKLER has been elected general manager of Clevite Corp. Weckler has been vice-president, operations, of Clevite since July 1953, when he first joined the corporation. For thirteen years, until May of last year, he had been vice-president and general manager of Chrysler Corp., where he was also a director. In his new position as vice-president and general manager, he will now have general responsibilities in all Clevite activities, including the corporation's central staff, and its research and development units.

Weckler

Heuser

JOHN E. HEUSER has been appointed to vice-president in charge of sales for the Le Roi Co., Milwaukee, Wis., a subsidiary of Westinghouse Air Brake Co. He will now be responsible for the organization and management of a newly-created Sales Division which will sell and service all Le Roi products. Heuser was sales manager of the company's Engine Division.

GARY GRAY SINTON has joined the McDonnell Aircraft Corp., St. Louis Airport, St. Louis, Mo. He was aerodynamic engineer for the Jacobs Aircraft Engine Co., Pottstown, Pa.

LEO I. GIBBONS, has retired as manager of the automotive section-field engineering department of B. F. Goodrich Co.'s Tire Division, Akron, Ohio. He was with the company for 41 years. At the Detroit Golf Club, Gibbons received congratulations and best wishes on the occasion of his retirement from his Akron and Detroit Goodrich associates.

Gibbons

Isbrandt

R. H. ISBRANDT has been appointed chief design engineer for the American Motors Corp., Nash Division. Isbrandt, who rejoined Nash in 1953, succeeds J. F. Sladky, recently deceased. He formerly was chief chassis engineer and chief aircraft engineer for Kaiser-Frazer Corp. Isbrandt had served with Nash as chassis designer from 1929 to 1936.

ROBERT V. RICHARDS has joined Macmillan Oil Co. of the Carolinas, Inc. in Charlotte, N. C. He was connected with Standard-Vacuum Oil Co. in Malaya and Siam for six years before becoming district manager for the Southeastern U. S. with Macmillan Petroleum Corp.

FREDERICK C. WEYBURNE, general manager of Marshall-Eclipse Division of Bendix Aviation Corp., Troy, N. Y., has been elected president of the Friction Materials Standards Institute. **WILLIAM J. NANFELDT**, general manager of the World Bestos Division of Firestone Tire & Rubber Co., New Castle, Ind., has been elected vice-president of the Institute.

SAE Members . . .

ALFRED SONNTAG, manager of the Sonntag Scientific Corp., a division of Baldwin-Lima-Hamilton Corp., has resigned this position to devote his time more exclusively to The Alpha Corp., Greenwich, Conn. Sonntag is president of the Alpha Corp. He will continue in an engineering consultant capacity for Baldwin-Lima-Hamilton.

WALTER A. OLEN has resigned as chairman of the board of the Four Wheel Drive Auto Co., Clintonville, Wis., but will continue as a member of the board. He was president of the company from 1910 to 1952 and board chairman since 1952.

Olen

Gassner

ALFRED A. GASSNER has been named vice-president, engineering, for Lunn Laminates, Inc., custom molder of reinforced plastics. Gassner is owner and chief engineer of Gassner Aircraft Engineering, New York City, design-engineers and consultants under exclusive contract to Lunn Laminates.

DR. WAYNE E. KUHN has been named general manager of the newly-created Research and Technical Department of The Texas Co., New York. This appointment fills a new executive post. Kuhn was manager of the technical and research division of the company. Until recently the research organization of The Texas Co. had functioned as a division of Refining. As the Research and Technical Department, it now has departmental status.

ROBERT W. WOLFE has become chief automotive engineer for the New Process Gear Corp. He was formerly manager of the advanced mechanism development section of the Westinghouse Atomic Power Division in Pittsburgh, Pa.

Wolfe

Reising

E. F. REISING has been appointed as assistant chief engineer for the Indland Mfg. Divison of GMC, Dayton, Ohio. He was recently assigned to the Dayton office to work on special assignments for the general manager.

Motor Wheel Changes

Hunt

Schweizer

J. HAROLD HUNT, vice-president in charge of automotive engineering of Motor Wheel Corp., Lansing, Mich., has announced his retirement. He has been with the company for twenty-six years.

ALBERT P. SCHWEIZER, previously executive engineer for Motor Wheel, has been elected vice-president in charge of automotive engineering by the board of directors and will now take over Hunt's duties.

R. A. CARLSON has been appointed as vice-president and manager of engineering for the Rockford Clutch Division of Borg-Warner Corp. at Rockford, Ill. Carlson has previously served as chief engineer and sales engineer for Rockford Clutch.

ROBERT WEST CONNOR is engineering program coordinator with the engineering staff at Ford Motor Co.'s engineering research department. He was formerly technical writer for the Chevrolet Motor Division of GMC in Detroit.

Promotions at Chrysler

H. RICHARD STEDING, III, has been promoted to chief engineer, executive staff, and **JOHN C. GUENTHER**, to director of technical information for the Chrysler Corp.'s Engineering Division. Steding, who has served as director of technical information since 1948, is now assigned to the corporation's organization department, and will also serve as a member of the management planning committee of the Engineering Division, and in various other staff assignments in planning and organization. He continues as a member of the Chrysler engineering board. He is a member of SAE's Publication Committee.

Steding

Guenther, who succeeds Steding as director of technical information, was assistant director of technical information in the Engineering Division. He is currently editor of SAE Detroit Section's publication, "The Supercharger," of which Steding was editor several years ago.

Guenther


Raviolo


Matthias


Kohr


Grebe


Tallberg

Ford Changes in Engineering . . .

A realignment of Ford Motor Co.'s engineering staff activities and responsibilities for product design and development for Ford, Mercury and Lincoln cars and Ford trucks has been announced by **EARLE S. MacPHERSON**, vice-president, engineering.

Principal changes are the establishment of two new vehicle engineering offices. The Lincoln and Mercury car engineering office is established with **VICTOR G. RAVIOLO** as director, and the Ford car and truck engineering office has been set up with **H. A. MATTHIAS** as director.

"These new engineering staff offices will be exclusively concerned with the engineering and coordination of products of the division with which they are identified," MacPherson said. "The engineering of certain important components of all vehicles produced by Ford Motor Co. will be retained in single operations within engineering staff."

The organizational changes also include the appointment of two additional directors. **R. F. KOHR** has been named director of the general engineering office, and **H. C. GREBE** has been named director of the body engineering and styling office.

MacPherson has announced the following appointments, as well: **V. Y. TALLBERG**, director of engineering administration and executive assistant to MacPherson; **WILLIAM K. BURTON**, executive engineer in charge of facilities and staff services, previously known as the administrative engineering office; **H. G. ENGLISH**, executive engineer, transmission and axle engineering; **N. L. BLUME**, executive engineer, Lincoln and Mercury car engineering; **F. E. SANDBERG**, executive engineer, truck engineering; **FRANK Q. HERSHEY**, chief of Ford car and truck styling, and **W. E. BURNETT**, executive engineer, Ford car engineering.

In addition, **ROBERT STEVENSON** has been appointed executive engineer, engines, and **P. H. PRETZ** has been named executive engineer, vehicles testing. Pretz will now have charge of Ford's new Michigan Proving Grounds and Arizona Proving Grounds and the test areas in Dearborn, Mich., and Jennerstown, Pa.


Burton


English


Blume


Stevenson


Hershey


Burnett


Sandberg


Pretz

MICHAEL GLUHAREFF, chief engineer of Sikorsky Aircraft, has received the American Helicopter Society's Dr. Alexander Klemin award for "notable achievment in the advancement of rotary-wing aeronautics."

E. O. HOLMGRAIN has become chief engineer for the Jay Madsen Equipment Co., Inc., Bath, N. Y., manufacturer of school bus chassis. He was consulting engineer for Superior Coach Corp.'s Bus Division, Lima, Ohio.

JOHN K. ZAISER is now design engineer in the surface controls section of North American Aviation Inc., Los Angeles. He was a mechanical engineer for John W. Galbreath & Co., Beaver Bay, Minn.

MAX REYNOLDS is with Industrial Supply Co., Bellingham, Wash., as sales manager, truck and equipment sales. Prior to joining Industrial, Reynolds was salesman for Truck & Tractor, Inc., Aberdeen, Wash.


Thelander

W. V. THELANDER has been appointed sales manager of clutches and farm equipment for the Dana Corp., Toledo. He will now have charge of all clutch sales and sales of all Dana products to the farm equipment industry, as well as to the earthmoving and off-highway manufacturers. Thelander was chief engineer of the Clutch Division of Dana.

PETER HOLD, previously member of the engineering faculty staff at McGill University's department of mechanical engineering, Montreal, Quebec, Canada, is now with the Canadian Car & Foundry Co., Ltd., Montreal.

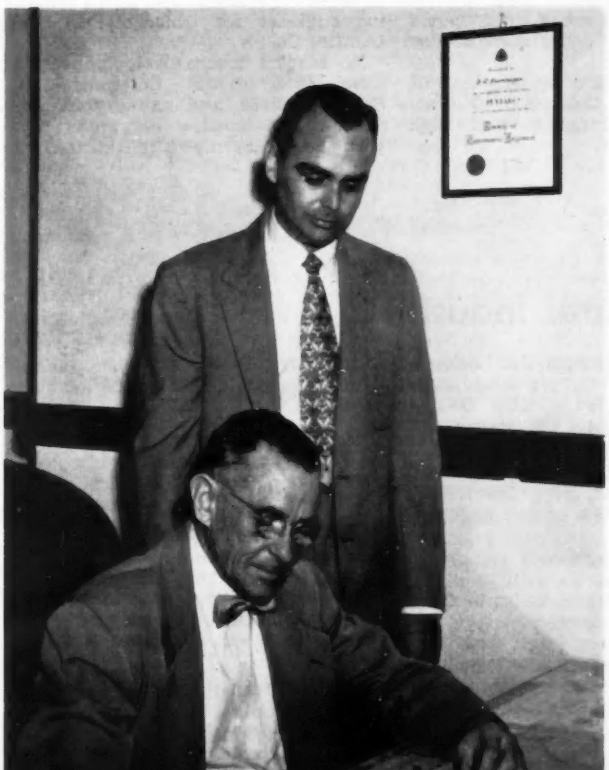
JOHN H. CREIGHTON is with the Pioneer-Central Division of Bendix Aviation Corp. He was with Boeing Airplane Co., Witchita, Kansas, as a junior engineer, "A."

RICHARD L. CHARLESWORTH is now sales representative for International Harvester Co. in Boston. He had been a sales representative for Mack Motor Co. of West Haven, Conn.

Harry Bryan Retires From International Harvester . . .

HARRY F. BRYAN has retired as assistant chief engineer of International Harvester Co.'s Industrial Power Division. He is shown at a retirement party given in his honor.

Bryan is a past chairman of the Chicago Section and is now serving on SAE's Diesel Engine Activity, as well as on CRC and ASTM committees. In 1948 he was SAE Vice-president representing the Diesel Engine Activity. He has made major contributions as an active participant in SAE technical administrative committee work for many years.



SAE

Father and Son

J. C. SLONNEGER (M'16) discusses a problem with his son, **ROBERT** (M'53). Slonneger senior is consulting engineer with the Continental Supply Co., Dallas, where he has been engaged in the design of oil well production equipment. He has been an active member of several SAE Sections, and at present is the senior member of the Texas Section.

Robert recently joined the mechanical engineering department at West Virginia University as an assistant professor. He was formerly on the faculty of the University of Texas. He served as chairman of the 1953-54 Student Committee in the San Antonio Division of the Texas Gulf Coast Section.

Obituaries

LUCIEN YEOMANS

Lucien Ingraham Yeomans, president of Lucien I. Yeomans, Inc., Chicago, died August 16. He was 76.

Yeomans was general superintendent, factories, for Sears Roebuck & Co.; superintendent, motive power, Armour & Co.; superintendent, Link Belt Machinery Co.; and superintendent, Heald Machine Co., before he established his own firm.

He had also worked for Brown & Sharpe Mfg. Co.; Woods Motor Vehicle Co.; and for Chicago Pneumatic Tool Co.

Though a native of Walworth, N. Y., Yeomans had been a resident of Chicago for the past 52 years. He was a nephew of President Grover Cleveland.

An SAE member since 1917, he was also a member of the American Society of Mechanical Engineers and the Western Society of Engineers.

WALTER G. D. CHANDLER

Walter George David Chandler, development engineer for Bendix Aviation Corp., South Bend, Ind., died in an automobile accident, July 17. He was 45.

Chandler had his start in the automotive trade just prior to his thirteenth birthday as an apprentice mechanic. After this period as apprentice, he spent four years in a machine shop until he qualified as a machinist. Then he returned to the garage business as an automobile mechanic. He held the position of mechanic, foreman, manager and proprietor, in that order.

When he became a member of SAE, in 1938, he was with the McQuay Norris Mfg. Co. of Canada. At McQuay Norris, he was service engineer, attending to complaints concerning parts that did not give satisfactory performance, diagnosed and effected proper repairs, and held clinics for the garage trade. He also called upon distributors to boost sales.

He later spent a short time with the Chrysler Corp., Windsor, Ontario, and was associated for several years with Bendix Eclipse and the Aircraft Hydraulic Supply Co. of Windsor. This was followed by two years in Montreal as president and engineering consultant of The Transportation Equipment and Engineering Co. For the past six years he had been with Bendix Aviation Corp. as development engineer in both automotive and aircraft divisions.

A collector of classic and antique cars, Chandler was one of the founders of the St. Joseph Valley Antique Car Club.

A Canadian Citizen, he was born at Victoria, British Columbia. He attended both elementary and high schools in Victoria.

RALPH DuBOIS

Ralph DuBois, chief product engineer of Ford Motor Co.'s Aircraft Engine Division in Chicago since 1951, died August 15. He was 56.

Previously, DuBois was a professor of aircraft engines and dean of the Aeronautic Institute of Technology at Sao Paulo, Brazil.

Prior to his employment by the Brazilian Ministry of Aeronautics at the Institute, DuBois had worked for Packard Motor Co., General Motors Corp., Continental Motors, and the National Bureau of Standards.

He was vice-president, representing SAE's Aircraft Engine Engineering Activity in 1938 and Chairman of the Detroit Section in 1945. He was presently a member of the Aircraft Powerplant Activity Committee.

HAROLD H. KLEIN

Harold H. Klein, 56, district engineer for National Motor Bearing Co., Inc., Detroit, died July 19.

Klein was experimental engineer for National Motor Bearing before he became district engineer at Detroit. He had also been sales engineer for Industries Equipment Co., and consulting engineer for Chicago Fuel and Utilities Co.

He studied mechanical engineering from International Correspondence School courses, and served mechanical and engineering apprenticeships with the Southern Pacific Railroad Co.

Students Enter Industry

K. SAMPATH (Madras Institute of Technology '53) is a designing engineer for Hindustan Motors, Ltd., West Bengal, India.

REUEL T. WERNER, JR. (Washington State College '54) is a second lieutenant in the U. S. Air Force.

ROBERT A. AIELLO (Lafayette College '54) is now a junior engineer for Link-Belt Co., Colmar, Pa.

HARVEY DAVID PRACE (University of Colorado '54) has joined Stromberg-Carlson Co., Rochester, N. Y. Prace is a junior mechanical engineer.

PAUL V. JEFFREY (Lawrence Institute of Technology) is a welding engineer for the Acme Tank & Welding Division of The United Tool and Die Co. of West Hartford, Conn.

BENJAMIN K. PORTER, JR. (General Motors Institute '56) is a cooperative engineer-student for GMC's Detroit Transmission Division, Ypsilanti, Mich.

HAROLD BURTON JONES (Michigan State '54) is with Ford Motor Co., Dearborn, Mich., as a project engineer.

PETER C. NYE (California State Polytechnic College '53) is with Shell Oil Co.'s Coastal Division, Ventura, Calif. Nye is a drilling engineer.

GERALD LAURIE LARSEN (Michigan State College '54) is an industrial engineer for Diamond Chain Co., Indianapolis.

GEORGE H. ELSNER (University of Illinois '54) is a graduate trainee at Ford Motor Co., Dearborn, Mich.

LEONARD J. BOUGE (Northrop Aeronautical Institute) has joined the U. S. Air Force.

GENE HILL (Oklahoma University '54) is with the Bendix Products Division of Bendix Aviation Corp., South Bend, Ind., as a junior engineer.

HOWARD FRANK TIETJEN (Stevens Institute of Technology '54) has a position in Los Angeles, Calif., in the capacity of junior engineer in the test and development of guided missile engines with North American Aviation, Inc.

WILLIAM J. CODERRE (Massachusetts Institute of Technology '54) is with the Bridgeport-Lycoming Division of Avco Mfg. Corp., Stratford, Conn. He is a junior engineer in the stress analysis group, Gas Turbine Division.

SAE Section Meetings . . .

Atlanta—Nov. 1

Ship-A-Hoy Restaurant. Octane Problems & Fuel Requirements Related to Future Engineering Developments—Casey Jones, Ethel Corp.

Baltimore—Oct. 19

Union Station, D. C. Meeting 9:00 p. m. Tour of Fort Belvoir, Va. at invitation of Wash. Sec.

Central Illinois—Oct. 25

Allis-Chalmers Plant, Springfield, Ill. Dinner 6:30 p. m., meeting 7:45 p. m. Air Cleaners—W. W. Lowther, sales engineer, United Specialities, Chicago, Ill. After dinner talk by the director of a boys' farm. Short sports film.

Cleveland—Nov. 1

Allerton Hotel. Truck & Bus Meeting.

Detroit—Oct. 18 and 25. Nov. 1

Oct. 18—Field Trip. Tour of Detroit Transmission Plant, Willow Run.

Oct. 25—Rackham Educational Memorial Bldg., Large Auditorium. Interesting Uses of High Strength, Low Alloy Steel in the Automotive and Allied Industries—Charles M. Parker, asst. vice president, American Iron and Steel Institute.

Nov. 1—Rackham Educational Memorial Bldg., Small Auditorium. Dinner Meeting. Design, Evaluation, and Selection of Heavy Duty Rear Axles—Kenneth Gordon, Chrysler Corp.

Kansas City—Oct. 12

World War II Memorial Bldg., Linwood & The Paseo, Kansas City, Mo. Dinner 7:00 p. m., meeting 8:00 p. m. Vehicle Service Problems—R. C. Hugo, motor vehicle methods supvr., S. Western Bell Telephone, St. Louis, Mo. There will be a short talk of 5 or 10 minutes by a well known business man on a subject of general community interest in addition to Hugo's talk.

Metropolitan—Oct. 4 and 20

Brass Rail, Fifth Ave. & 43rd St., New York, N. Y. Cocktail Hour 5:30 p. m., Dinner 6:30 p. m., meeting 7:45 p. m. Vickers Viscount Turbo Prop Planes—Gordon R. McGregor, president, Trans-Canada Airlines.

Oct. 20—Engineering Societies Bldg., 29 West 39th St., New York, N. Y., 5th floor. Meeting 7:45 p. m. Ford Thunderbird Sports Car—Representative, Ford Motor Co.

Milwaukee—Nov. 5

Athletic Club. Dinner 6:30 p. m., meeting 8:00 p. m. Pin Wheels or Pistons—W. A. Turunen, Head Gas Turbines Dept., Research Labs., General Motors Corp., Detroit, Mich.

Mohawk-Hudson—Nov. 9

Circle Inn, Latham, N. Y. Dinner 6:30 p. m. Tour Alleghany Ludlum Steel Corp.

New England—Nov. 9

M. I. T. Faculty Cambridge. Dinner 7:00 p. m., meeting 8:00 p. m. Temperature Control—Why? How?—David R. Ferris, vice president engineering, Kysor Heator Co., Cadillac Mich. Cocktail hour sponsored by Kaysor Heator Co.

Oregon—Nov. 10

Congress Hotel. Dinner 7:00 p. m., meeting 8:00 p. m. Better load distribution for more pay load—M. C. Horine, consulting engineer, Mack Mfg. Corp., Somerville, N. J.

Philadelphia—Oct. 13

Engineers' Club. Dinner 6:30 p. m., meeting 8:00 p. m. Trends in Engines, Fuels and Vehicles (panel discussion) —Darl F. Coris, General Motors, Research, and Fred Hague, Sun Oil Co.

Pittsburgh—Oct. 26

Mellon Institute. Dinner 6:00 p. m., meeting 8:00 p. m. Materials and Power—Now and in the future—Norman L. Mochel, mgr., Metallurgical Engineering, Westinghouse Elec. Corp., Philadelphia, Pa. Joint ASTM-SAE meeting with Mr. Mochel (Nat'l ASTM president) as the principal speaker.

St. Louis—Oct. 12

Gatesworth Hotel, St. Louis Mo. Dinner 6:30 p. m., meeting 8:00 p. m. Fantastic 500. Indianapolis Speedway Race—Frank A. Gerardot, engr., Bardahl Oil Co., St. Louis, Mo. Thirty minute film of the race and a talk on the engineering highlights of the race. We hope to have George P. Dorris talk on the cars of the early 1900's in contrast to today's models.

San Diego—Oct. 12

Auditorium—Solar Aircraft. Dinner 6:30 p. m., meeting 7:45 p. m. Electronic Reliability Problems. Panel Discussion—H. F. Eppenstein, electronics design engr., Convair, San Diego, Calif., and M. Brady, Lab. Test Engr., Convair, San Diego, Calif. C. F. McCabe, Moderator, asst. chief engr., Sand Diego div. Convair.

San Diego—Nov. 2

Lang Morst Cafe, Solar Aircraft Co. Auditorium. Dinner 6:30 p. m., meeting 7:45 p. m. Program to be announced.

Southern California—Nov. 8

Rodger Young Auditorium. Dinner 6:30 p. m., meeting 8:00 p. m. Design Features of the Douglas A3D Sky Warrior—Harry A. Nichols, Proj. engr. —A3D Airplane, Douglas Aircraft Co., Inc., El Segundo Div., El Segundo, Calif.

Southern New England—Nov. 3

Springfield, Mass. Dinner 6:45 p. m., meeting 8:00 p. m. Latest developments in small gasoline engines—Sheldon D. Pollow, chief engr., Power Products Corp., Grafton, Wisconsin.

Spokane-Intermountain—Nov. 4

Desert Caravan Inn. Dinner 6:00 p. m., meeting 7:00 p. m. Better Load Distribution for Pay Load—Merril C. Horine, consulting engr., Mack Motor Truck Corp., New York, N. Y.

Syracuse—Nov. 10

Fine Art Museum. Dinner 6:30 p. m., meeting 8:00 p. m. Refrigeration & Air Conditioning of Road Transport Vehicles—Larry Hogan, member of ASRE. Private Car Air Conditioning —Frank Cartor, Detroit Lubricating Co., Detroit. Frank Cartor has a model car which has an air conditioning unit.

Texas—Oct. 8. Nov. 12

Oct. 8—Transportation & Maintenance

Nov. 12—Aircraft Design

Texas Gulf Coast—Oct. 8

Ye Olde College Inn, Houston, Texas. Dinner 7:00 p. m., meeting 8:00 p. m. Torque Converters in Service—R. M. Schaefer, mgr. of transmission engr. dept., Allison Div. of General Motors, Indianapolis, Ind.

Virginia—Oct. 25. Nov. 22

Oct. 25—Speaker from Spicer mfg. Div., Dana Corp.

Nov. 22—Use of L P gas as a Motor Fuel—F. E. Selim, Phillips Pet. Co.

Washington—Oct. 19

Field trip to the Engineering Research and Development Laboratory at Ft. Belvoir, Va. Time—9 a. m. to 3:30 p. m. Program will consist of a general inspection of the ERDL facilities, examination of latest engineer equipment, and demonstrations of floating and fixed bridging operations. Other topics to be covered are Ease of Maintenance and the engine standardization program for engineering vehicles.

Williamsport—Oct. 4

Moose Club. Dinner 6:30 p. m., meeting 7:45 p. m. Pinwheels or Pistons—J. S. Collman, research lab. div., General Motors Corp., Detroit, Mich.

Good Commercial Nodular Irons Rival Steel in Strength, Ductility

Prof. Richard Schneidewind,

Dept. of Chemical and Metallurgical Engineering
University of Michigan

Report to Division IX, Automotive Iron Castings of the SAE Iron and Steel Technical Committee.

Nodular irons offer attractive properties for automotive and tractor parts. The combination of strength, and ductility approaches that of steel and the properties are superior to those of malleable and gray irons. The castability—which can affect the final casting—is superior to that of steel and malleable iron, although inferior to gray iron. This type of material has already been successfully used for crank shafts, cylinder heads, pistons, and similar parts in automotive, truck, and diesel work.

Gray cast iron, malleable cast iron, and nodular cast iron may be looked upon more or less accurately as steel containing graphite. It is obvious that their properties will be determined in part by the graphite and in part by the steel-like matrix of ferrite, pearlite, tempered martensite, or other structure.

Perhaps the most important factor in determining the properties of cast irons and in distinguishing them from those of steels lies in the quantity and the size, shape, and distribution of the graphite. In gray irons, the graphite appears as a flake. In this form it interferes greatly with the continuity of the matrix and the ends of the flakes may act as internal notches or stress raisers. In malleable irons the graphite exists in compacted aggregates leaving considerable free space of matrix between. This structure is responsible for the fact that malleable irons have ductility whereas gray irons have less than 1% elongation. In nodular irons the graphite approaches a true sphere. There is minimum interference with the continuity of the matrix, resulting in strengths and ductilities which in some cases closely approach those of the steel-like matrix.

Nodular irons are formed by the addition of small amounts of magnesium or cerium, sufficient to leave a residual content of approximately 0.05%. If the iron is properly made it may be cast into small sections to produce a white iron which upon annealing produces nodular graphite. Casting at slower cooling rates, proper adjustment of the composition, or inoculation with silicon may produce nodular graphite as cast. Nodular castings have been made successfully with section sizes in the neighborhood of from ¼ in. to over 6 in. in diameter. Even larger castings have been reported.

A better understanding of the properties of nodular iron may be gained by comparing the specifications of this product with those of malleable iron and plain steel castings. Table 1 shows

Table 1—Minimum Properties of Cast Irons

		Tensile Strength, psi	Yield Point, psi	Elongation, %	Brinell Hardness	Condition
	ASTM A-47-52					
Malleable Iron	Grade 32510	50,000	32,500	10	—	—
Malleable Iron	Grade 35018	53,000	35,000	18	—	—
	ASTM A-220-50					
Pearlitic Malleable	Grade 43010	60,000	43,000	10	163–207	—
Pearlitic Malleable	Grade 48005	70,000	48,000	5	179–228	—
Pearlitic Malleable	Grade 53004	70,000	53,000	4	197–241	—
Pearlitic Malleable	Grade 60003	80,000	60,000	3	197–241	—
Pearlitic Malleable	Grade 70002	90,000	70,000	2	241–285	—
Carbon Steel	SAE 0022		not specified			—
Carbon Steel	SAE 0030	65,000	35,000	24	131	—
Carbon Steel	SAE 0050	85,000	45,000	16	170	—
		100,000	70,000	10	207	—
Carbon Steel	SAE 080	80,000	40,000	18	163	—
Low Alloy Steel	SAE 090	90,000	60,000	20	187	
	ASTM A-339-SIT					
Nodular Iron	Grade 60-45-10	60,000	45,000	10	—	annealed
Nodular Iron	Grade 80-60-03	80,000	60,000	3	—	as-cast
	U. S. Army Ordnance MIL-1-17166A					
Nodular Iron	1 (120-90-02)	120,000	90,000	2	—	normalized, quenched & drawn
Nodular Iron	2 (100-75-04)	100,000	75,000	4	—	normalized and drawn
Nodular Iron	3 (85-60-06)	85,000	60,000	6	—	as-cast
Nodular Iron	4 (80-60-03)	80,000	60,000	3	—	as-cast
Nodular Iron	5 (60-45-10)	60,000	45,000	10	—	annealed
Nodular Iron	6 (60-40-18)	60,000	40,000	18	—	annealed

the specifications for these materials. There is a size limitation in malleable castings which makes it difficult to produce satisfactory castings commercially with sections over 2 in.

Mechanical Properties of Nodular Irons

The tensile modulus of elasticity of nodular irons has been measured between 22,000,000 and 25,000,000 psi. It is therefore slightly less rigid than malleable irons and definitely less rigid than steel. Nodular iron exhibits a constant ratio of tensile strength to Brinell hardness. Where the nodules are satisfactorily spherical, the T/B ratio varies between 420 and 470 in good commercial practice. This compares with a similar ratio of about 485 to 530 in the case of steels. Where the T/B ratio of nodular iron falls much below 420, the cause is due to either a defect in the iron, to the presence of massive carbides, or to the fact that nodules deviate appreciably from true sphericity. The most noticeable result of imperfect nodules will be found in reduced ductility.

The matrix of nodular iron in the condition as-cast may be ferrite, pearlite or a mixture of these. Since nodular iron can be quenched and tempered, structures varying from tempered martensite to spheroidized pearlite can exist. By special alloying, austenitic nodular irons and acicular (bainitic) nodular irons have been produced. Rather than go into detail as to the microstructure, the properties of nodular iron will be discussed in two categories: as-cast and heat-treated. Fig. 1 shows the relationship in as-cast, 1-in. keel block test specimens between Brinell hardness of nodular iron and the tensile strength, yield strength and elongation. The boundary areas shown in the graph have been plotted from data comprising over eight months of daily operation in one foundry, plus a large number of other data, all from commercially-prepared heats.

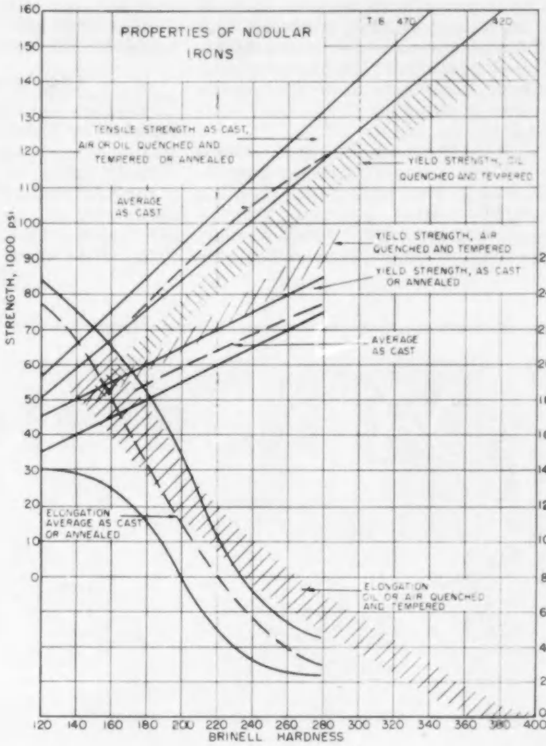


Fig. 1—Variation of tensile strength, yield strength, and elongation with Brinell hardness

As-Cast Nodular Irons

The area lines for tensile strength are the lines representing the T/B ratios of 420 and 470 respectively. Less than 2% of the points fell outside these limits. The dotted line shows the most frequent strengths obtained with as-cast irons. Nodular irons which had been heat-treated had strengths falling in this same area.

It is safe to say that the iron having a Brinell hardness under 170 is predominantly ferritic, whereas that above this hardness is predominantly pearlitic.

The yield strength data for as-cast materials are presented as a parallel band. Again the dotted line shows the average of results measured. In irons in the as-cast condition, the ratio of yield strength to tensile strength is somewhat low, varying from 65% to slightly over 80%. Some manufacturers have had difficulty in satisfying a yield point specification without having the tensile strength considerably higher than specified. This occurs because the specifications are based on somewhat higher yield-to-tensile ratios.

The relationship between Brinell hardness and elongation for as-cast irons is shown in the curved range at the bottom of the chart. An average value for production heats as-cast is indicated by the dotted line. Although no statistical analysis was made, it was observed that for any given hardness the elongation is higher if the T/B ratio is high and lower with a lower T/B ratio.

At the left-hand portion of the chart it may be seen that the property limits carry over as expected even though about half of the points in this zone were obtained on annealed nodular irons and half on irons as-cast. Where care was exercised in selecting raw materials so that manganese and other pearlite-stabilizing elements were absent, approximately the same mechanical properties were obtained as in the as-cast state as after a full anneal.

Annealed Nodular Irons

As pointed out in the previous paragraph, the difference between annealed (ferritic) nodular irons and those which were ferritic as-cast is slight. The completeness of annealing in commercial practice varies from plant to plant, but no difficulty should be experienced in meeting the military specifications for this type of material. Annealed irons naturally are completely stress relieved and the carbides more fully decomposed than is the case with ferritic as-cast irons. The toughness and ductility are therefore somewhat superior.

The strength of nodular irons increases and the ductility decreases with increasing silicon. Where subzero impact is important, the silicon should be kept below about 2.5%.

Heat-Treated Nodular Irons

Somewhat different properties may be secured by heat-treatment. The data presented here on heat-treated nodular irons have been obtained from commercial work which confirm the earlier findings of J. E. Rehder (as given in "Iron Age," Vol. 169, No. 3, Jan. 17, 1952, pp. 89–93.) These treatments involve austenitizing, oil quenching, and tempering, or austenitizing, air quenching, and tempering. Reference to Fig. 1 shows clearly that the relationship between Brinell hardness and tensile strength is not altered by oil quenching and tempering, or by air-quenching and tempering.

There is, however, an increase in yield-to-tensile ratio so that for any given hardness the yield strength of oil-quenched and tempered irons is considerably higher than in irons in the as-cast condition. Where irons have been air-quenched and tempered,

the yield strengths lie between those of the oil-quenched and tempered and of those as-cast as shown in the figure.

The elongations of the quenched and tempered irons seem to be appreciably superior to those in the as-cast condition.

These differences between heat-treated and as-cast material may be explained in part by the fact that the untreated casting contains internal stresses and perhaps a small amount of massive carbide. These conditions may not appreciably detract from the strength but will first manifest themselves in low ductility values.

Other Heat-Treatments

Nodular iron castings may be stress relieved by heating for one hour per inch at temperatures from 1000–1250 F. Usually the stress relief is confined to a range of 100–1100 F in order not to decompose an appreciable share of the pearlitic carbides. Stress relief is of little value when the original casting contains free cementite and instead, heat-treatment above the critical is required.

Flame hardening can readily be performed on pearlitic grades of nodular iron in the same manner as it is carried out for pearlitic gray iron and for pearlitic malleable iron.

Welding and Machining

The machinability of nodular iron is roughly a function of its Brinell hardness. However, it has been found that at any given hardness the machinability is usually better than for a gray iron of the same hardness.

Nodular irons can be successfully brazed with a silver soldering alloy at a temperature which will not cause any change in structure and properties. Welding however can easily lead to a condition of inferior properties around the weld. In the heat-affected zone the metal is recarburized and will therefore show lower ductility. A heat-treatment is required to recover the properties. This is especially true if the original casting is ferritic. Successful welds have been made with iron-nickel alloy welding rod.

Dynamic Properties

Notched Charpy impact strengths of ferritic nodular irons are in the neighborhood of 20–40 ft-lb. A transition temperature in higher silicon irons, over 2.5%, has been found to be dangerously near room temperature where the impact drops to below 5 ft-lb. Where low temperature impact is important, it is generally considered wise to specify a low silicon material. Pearlitic irons range in the neighborhood of 10 ft-lb.

The endurance ratio of nodular irons is in about the same order as that of steel, namely about 50% of the tensile strength. For the soft, ferritic grades the ratio will usually lie between 50 and 55% and for the stronger grades, between 45 and 50%. Nodular irons are more notch sensitive than gray irons.

Committee E-21 Undertakes Standardization of Marking

A special panel to handle specifications for the marking of aircraft engine parts has been established. It is a subsidiary of Committee E-21, General Standards for Aircraft Engines of the SAE Aircraft Engine Division.

E-21 Chairman Robert F. Schwarzwalder, who has been named to serve again for the 1954–1955 term, has appointed H. B. Slusher chairman of the new panel.

Aero Materials Specs Reviewed by Industry

DRAFTS of twenty-one SAE Aeronautical Materials Specifications are currently being circulated to industry for comment and criticism by the SAE Aeronautical Materials Specifications Division.

Copies of all of these specifications are available for review from the SAE Aeronautical Department, 29 West 39 Street, New York 18, N. Y.

The specifications under review are:

- AMS —— Steel Castings, Precision Investment, Corrosion Resistant 16Cr-2.3Ni;
- AMS —— Steel Castings, Precision Investment, Corrosion Resistant 17Cr-4Ni-4Cu;
- AMS —— Bolts and Screws, Steel, Corrosion and Heat Resistant, Heat Treated—Roll Threaded;
- AMS —— Plastic Sheet: Laminated Paper Base, Phenolic Resin Copper Faced;
- AMS —— Plastic Sheet: Laminated Glass Fabric Base, Epoxy Resin, Copper Faced;
- AMS —— Steel Castings, Sand, Corrosion Resistant, 17Cr-4Ni-2.7Cu;
- AMS —— Steel Castings, Sand, Corrosion Resistant, 15.8Cr-1.9Ni;
- AMS —— Steel, Low Alloy Heat Resistant, 1.25Cr-0.65Si-0.5Mo 0.85V (0.20-0.25C);
- AMS —— Steel, Low Alloy Heat Resistant, 1.25Cr-0.65Si-0.5Mo 0.85V (0.25-0.30C);
- AMS 33XX—Silicone Rubber Sheet, Glass Fabric Reinforced Improved Strength Silicone;
- AMS 2400K—Cadmium Plating;
- AMS 2671A—Copper Furnace Brazing, Corrosion and Heat Resistant Steels and Alloys;
- AMS 3197E — Synthetic Rubber Sponge, Chloroprene Type—Soft;
- AMS 3198E — Synthetic Rubber Sponge, Chloroprene Type—Medium;
- AMS 3199E — Synthetic Rubber Sponge, Chloroprene Type—Firm;
- AMS 3630B—Plastic Extrusions, Flexible, Vinyl Chloride Acetate;
- AMS 3635—Plastic Sheet and Moldings, Cellular, Shock Absorbing;
- AMS 4040D—Aluminum Alloy Sheet and Plate, Aluminum Covered 4.5Cu-1.5Mg-0.6Mn (Alc 24S-0);
- AMS 4041D—Aluminum Alloy Sheet, Aluminum Covered, 4.5Cu-1.5Mg 0.6Mn (Alc 24S-T3);
- AMS 4042D—Aluminum Alloy Sheet, Aluminum Covered, 4.5Cu-1.5Mg 0.6Mn (Alc 24S-T36);
- AMS 5566C—Steel Tubing, Corrosion Resistant, 19Cr-10Ni (SAE 30304), High Pressure Hydraulic.

Three Sources Furnish Quality Control Training

Based on report by

RICHARD EDE

U. S. Steel Co.

ENGINEERS are now getting statistical quality control training from three main sources—from universities and colleges, from in-plant courses, and from courses given cooperatively by educational institutions and industry.

Beginning courses in universities generally emphasize process control and acceptance sampling. In the first instance, various types of control charts are studied. In acceptance sampling, the control charts are considered and the various sampling tables and plans investigated. There is a tendency to consider the subject in very broad terms and to take up the many applications.

Most institutions make the courses elective, and in some the work can be continued until the Ph.D. is attained.

In-plant training has developed in various ways. In some instances a supervisor became interested and tried out procedures in cooperation with some operators. In other cases, after making a pilot run, top management took the initiative.

One company held a one-day meeting attended by the board of directors, president, vice-presidents, attorney, and other key persons. They went over certain aspects of the program with their quality control director. Later, two-day regional meetings were held with key personnel in each plant, followed by one or two persons in each plant spending 10 days in studying additional aspects.

Another concern had works managers attend a two-day conference which was addressed by the president, executive vice-president and quality control personnel. The works managers constructed control charts and took up aspects of acceptance sampling. After the conference each works manager selected one or two capable men for a two-week in-plant training course.

In still another plant, the quality control director instituted a control chart in cooperation with a department manager. Results were such that use of the charts spread throughout the organization, including the offices. All department managers meet once a month to review the charts so that each can see what other units are doing.

Cooperative courses have made an important contribution. During the last war, over 30 so-called eight-day courses were sponsored, to a large extent, by the War Production Board and the U.S. Office of Education under the Engineering, Science and Management War Training Program, in cooperation with educational institutions. Following the war, a few schools continued these courses on a fee basis.

It was thought that the courses would have served their purpose after a period of a few years. This was not the case. As a company secures one or two trained persons, need for additional trained personnel becomes apparent. Representatives are often sent for a short course sponsored by an educational institution. Later, these trainees return to meet with the instructors to check on procedures and methods.

Advanced eight-day courses have been developed and sponsored largely for the benefit of the graduates of basic intensive courses, or their equivalents. There have also been cooperative evening or part-time courses. These sessions may run from one to three hours and last for several weeks. The armed services have given train-

ing courses, some of which have been most helpful to the industries involved. Finally, excellent courses have been sponsored by several sections of the American Society for Quality Control and the educational programs at the regional and national conventions of the Society. These courses are often given in cooperation with other organizations.

(This article is based on the secretary's report of the panel on Inspection and Quality Control, of the Production Forum at the SAE National Production Meeting, Chicago, March 29, 1954. The complete report, together with those of the other seven panels at the Forum, are available in multilithographed form from the SAE Special Publications Department as SP-306. Price: $1.50 to members, $3.00 to nonmembers. Members of the panel were: J. J. Halton, leader, Deere and Co.; Richard Ede, secretary, U. S. Steel Co.; L. A. Knowler, University of Iowa; A. C. Richmond, International Harvester Co.; Arthur Bender, Jr., Delco-Remy Division, GMC; W. E. Jones, Management Controls.)

What Truck Users Want in Performance

C. T. KOPE

Ford Motor Co

FLEET operators would like to have light trucks able to climb a 5% grade at a minimum speed of 30 mph. They want buses capable of going up a 4% grade at a minimum of 25 mph. And they would settle for a minimum speed of 20 mph on a 3½ to 4% grade for heavy over-the-road trucks.

When it comes to road speeds of 50 to 60 mph, horsepower is of prime importance. Combined gear ratios and tire sizes play an important role in vehicle performance, but it's horsepower that moves a given load at a given speed. Auxiliary transmissions and rear axle ratios are made to satisfy gradeability requirements so that a vehicle may operate at maximum efficiency both as to economy and speed. Over-gearing results in poor performance and short engine life, while under-gearing means slower speeds with resultant economic loss. The designer can provide the correct engine, transmission, and axle ratios, but it is still up to the operator to make the proper selection.

No one class of road user can lag behind in the minimum performance levels demanded by our mobile society. And that poses a problem in regard to the power required to enable tractor-trailer combinations to keep up with traffic. The most common maximum legal axle load is 18,000 lb and a typical combination would gross, say 56,000 lb. To move a 60,000 lb load at about 50 mph requires an increase of 20 hp for each ¼% gain in gradeability. A study also has shown that a 4½% gradeability is the equivalent of 1 mph acceleration on a level road.

To put the tractor-trailer in the same speed range as the passenger car is out of the question. It can't be done with horsepower. The answer must come from better highways and traffic control. Trucks have adequate speed for highway operation if the friction in congested traffic and on grades can be eliminated.

Operators of small trucks would like their units to blend in with urban and suburban traffic. Urban performance is satisfactory in view of traffic conditions, since it is fact that pick-up trucks operate less miles per day,

month, and year than they did in Model T days, despite greater speed and acceleration. To keep up with suburban traffic they need to be able to accelerate from 10 to 50 mph in 20 sec, and anything less than 85 usable horsepower would be undesirable for overall performance.

The modern concept of load moving must also take the driver into consideration. He must be confident of his controls and his control of the vehicle. Controls must be within easy reach and he must be comfortable. Truck ride could be improved considerably, but it is complicated by the varying conditions of no load to full load encountered.

(This article is based on the secretary's report of Round Table on "What Are the Performance Characteristics Desired by the Operator, Covering Acceleration, Gradeability and Roadability" held at the SAE Summer Meeting, Atlantic City, June 8, 1954. Leader of the Round Table was F. E. Sandberg, Ford Motor Co. Members were Fred Lautzenhiser, International Harvester Co.; S. J. Tompkins, Chrysler Corp.; M. E. Nuttila, Cities Service Oil Co.; J. B. Hanson, General Services Administration, U.S. Government; F. K. Glynn, Am. Tel. & Tel. Co.; M. T. Hayes, General Motors Corp.)

Basic Concepts Of Combustion Process

Based on paper by

J. C. PORTER

Cities Service Research & Development Co.

IN his paper, the author describes the air-standard cycle, idea fuel-air cycle and fundamental concepts of a spark-ignition engine. Also reviewed are the effects of combustion processes on power, efficiency and composition of exhaust products at various air-fuel ratios. Formulae and charts are included. (Paper "Combustion Effects" was presented at SAE Metropolitan Section, New York, April 15, 1954. It is available in full in multilithograph form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Using Inspection For Process Control

Based on paper by

HAMILTON MIGEL

Magnaflux Corp.

MAGNETIC particle and penetrant inspection, such as Magnaflux and Zyglo, are particularly well adapted for use as production tools. They are basically simple and with properly designed equipment can be used to inspect high volumes of parts at rates up to 2000 per hr and at a cost down to less than a cent a piece for small units.

Cost of equipment and materials, using the magnetic particle method, is usually a small factor compared with the cost of man hours required for handling and inspection. And in many cases it is possible to eliminate handling by integrating the inspection

into the parts handling system already in use.

Penetrant inspection is also used extensively as a means of lowering costs through production control. It may be either fluorescent penetrant such as Zyglo or dye penetrant such as Spotcheck. The former is particularly well adapted to production testing because the indications can be observed more quickly. It is especially useful for production control of parts fabricated from high temperature alloys used in the manufacture of jet engines. One of the most critical parts, the turbine bucket, is usually inspected at least twice prior to final inspection, once as-forged and once after rough machining. This eliminates forging defects prior to the final expensive finishing.

Penetrant inspection is an excellent process control tool for a wide variety of welded tanks and containers which must be free from leaks. Most containers are subject to a final leak test after assembly. Penetrant inspection permits testing of sub-assemblies, thus reducing repair or re-work costs. (Paper "Magnetic Particle, Penetrant and Related Inspection Methods as Production Tools for Process Control" was presented at SAE Summer Meeting, Atlantic City, June 9, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Normal Eye Best For Color Matching

Based on paper by

R. I. PETERS

and

H. W. REDSHAW

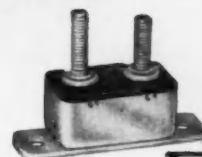
Ditzler Color Div., Pittsburgh Plate Glass Co.

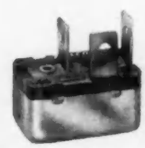
COLOR is the physiological sensation produced when reflected light of wavelengths between 400 and 720 millimicrons are received by the normal eye. A partially color-blind person can be a tinter, but a person with defective vision has a much more difficult task making the color decision than a person with normal vision. The human eye is the final answer on color match. Therefore, any person embarking on a paint career involving color problems should submit to the Color Blindness Test such as was used by the Armed Forces in World War II.

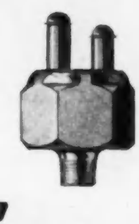
Some of the peculiarities of color matching can be explained by considering a few of the technical problems. A green pigment in white light appears green because it absorbs almost all of the other wavelengths and reflects the wavelength of green. If a light source other than white light is used, as for example one which is deficient in blue wavelengths, the green color resulting will be of a different wavelength and consequently a different shade of green.

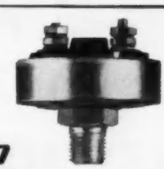
Each type of green pigment exhibits its own characteristics with respect to the wavelengths absorbed and reflected. For this reason no two green pigments will appear alike in lights of different wavelengths. This is true of all pigment colors. The tinter, therefore, in matching a new color for the first time, must use pigments of the same type as were used in the original color to get a match in more than one type of light.

Why bother with more than one type of light? Because natural daylight varies in quality during the day. Early daylight is deficient in blue and green









because the longer path of the sun's rays through the earth's atmosphere absorbs most of these wavelengths. The same is true of evening twilight. North light contains fewer red rays than direct sunlight. Consequently, unless the tinter knows what pigments were used in the original color, he must, by trial and error and past experience, combine the various pigments until the color is matched in sunlight and north light, or in daylight and artificial light, or even in two types of artificial light if they differ in wavelength. Then, and only then, will he have a complete color match.

Machines for tinting have been developed, but they are more successful in analyzing the color produced than in indicating what must be added and in what amount. The General Electric Spectrophotometer does produce a permanent record of a color, and this is important since paints, being organic, are not completely permanent either in wet form or as the dried film. The instrument is too costly for most laboratories and its value as a tinting aid is questionable. Other colormeters measure reflection of filtered light and may be used. Panels are recommended as the post permanent color standard; they may discolor on storage, but can be bleached by sunlight.

(Paper "Evaluation of Automotive Finishes" was presented at SAE National Passenger Car Body & Materials Meeting, Detroit, March 2, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Space is Big Item In Car Conditioning

Based on paper by

D. C. PERKINS

and

A. D. BAKER

Oldsmobile Div., General Motors Corp.

AIR conditioning of a passenger car as contrasted with the cooling of a home or a railroad coach is complicated by the relatively low space per person, high refrigeration load, and low space to air delivery ratio.

Air Conditioning Unit Comparisons

	Window Unit	Railroad Coach	Oldsmobile
Space per person	567 cu ft	89 cu ft	27 cu ft
Refrigeration	0.76 tons	7.5 tons	1.25 tons (at 35 mph)
Space to air delivery ratio	11.3	2.1	0.73

The interior of a car is subjected to high radiant heat load by virtue of the large ratio of glass to total surface area. And engine and exhaust system contribute materially to the high heat load.

The capacity of the Oldsmoble conditioning unit at 50 mph is 20,000 BTU per hr, or approximately 1-2/3 tons, whereas a 1 hp room conditioning unit has a 9000 BTU per hr capacity.

(Paper "Oldsmobile Car Conditioning System" was presented at SAE Dayton Section Meeting, May 24, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Develops Yardstick To Aid Bus Operators

Based on paper by

E. F. LEWIS

General Motors Corp., GMC Truck & Coach Division

UNLIKE the trucking industry which has been expanding by leaps and bounds, bus transportation has been declining. Since 1942, motor bus equipment has decreased 6%, passengers carried has fallen 17% with only 8% decrease in mileage and, since the peak year of 1946, the drop in passengers has been nearly 40%.

Faced with this general situation and believing that a company must earn a fair share of profit to survive, which in turn requires an intimate knowledge of costs, Paul O. Dittmar, president of a suburban Chicago bus line, developed what he called Standard Pars. They represent an initial ratio of percentages for all major items of operational cost in relation to gross revenue. Standard Pars provide a yardstick or means for measuring the efficiency standard being achieved in the several cost categories of operation. It helps management to spot quickly the troublesome areas that must be improved.

Any such formula, or ratio of percentages, cannot remain static, but must be continually reviewed and revised as practical ways and means of improvement are developed. As they exist today the standards are as follows:

Transit Par	Percentage
Cost of Personnel	
Executive, Administrative, Supervisory	6.00
Secretarial, Clerical, Office, and Such	3.00
Maintenance, Repair, Servicing	9.00
Total Non-Operating Personnel	18.00
Operators	32.00
Total Personnel Costs	50.00
Cost of Goods and Services Purchased	18.00
Cost of Accidents	4.00
Total Controllable Costs	72.00
Cost of Depreciation	8.00
Cost of Government	
Direct Taxes only	4.00
Federal Income Taxes	8.00
Total Operating Cost	92.00
Net Operating Profit—(Available for debt service charges, retirement of debt, dividends, improvements and additions to properties, and contingencies)	8.00

(Paper "Bus and Fleet Operation" was presented at SAE Western Michigan Section, Muskegon, Feb. 11, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Goal for Helicopter Parts: Longer Life, Warning of Failure

BARTRAM KELLEY, Bell Aircraft Corp., Chairman

SAM GORDON, Battelle Memorial Institute

PAUL KUHN, National Advisory Committee for Aeronautics

P. A. SIMMONS, JR., Wright Air Development Center

FATIGUE strength of metal parts—especially of rotor blades—is receiving more and more attention from helicopter designers.

Primarily they are out to increase service life of cyclicly stressed parts. But they know that failure will come sooner or later in parts stressed beyond their endurance limit. When failure does begin, they want to have it de-

tectable before it presents a flight safety problem.

Here are some of the topics that are concerning helicopter engineers studying fatigue life:

Shot Peening—Sometimes shot peening is beneficial to the service life of parts, sometimes not. When it is beneficial, it is probably because the peening operation cements together the surface layers of the part and closes up the tiny surface cracks that might otherwise serve as stress raisers at which fatigue failures could start.

Since there is no one easiest path for a crack to follow in a shot peened specimen, the specimen tends to act like the "one-hoss shay." Instead of a gradual, detectable crack, there is a more sudden, generalized failure. The part may last longer under fatigue loading, but failure is likely to develop faster once it starts.

Bonding Versus Riveting—Some manufacturers have tried bonding the rotor blade to the hub. Their reason is to avoid rivet holes, which are stress raisers.

The trouble is that the bonding media are relatively new and haven't yet completely proved themselves to everyone's satisfaction. So even among bonding proponents there is the temptation to add a few rivets for insurance—which introduces the stress raisers.

Rivets do have an inspection advantage: Cracks around rivets show up. Failures in the bond don't.

Inspection Aid—It might be possible to imbed three special wires in an adhesive-coated "plaster" that could be applied like a strain gage to a part subject to repeated stressing. The wires would be chosen so that when two out of three failed, the inspector would know that the part was due for retirement.

Composite Structures—The S-N (stress versus number of loading cycles) curve for a composite structure is really an envelope curve for a number of S-N curves of points in the structure that can fail.

Battelle Memorial Institute has developed a specimen that will simulate a composite structure and produce failures where they are wanted for test purposes.

Test Loading Speed—The faster loading cycles can be applied, the less time it takes to obtain fatigue data. The National Advisory Committee for Aeronautics has found that the speed of loading does not influence results as long as loading is between 100 and 11,000 cpm.

During the test, there must be no corrosion and no temperature or other environmental change.

High-speed resonance testing of rotor blades does not give realistic loading over the whole span of the blade, and the loads can be controlled only at a given point.

The qualification tests of components should probably be done as complete assemblies, because in a simple test specimen it is difficult to duplicate the load spectrum obtained on an assembly. For example, tests on rotor hubs involve relatively simple load spectrums; tests on rotor blades involve quite complex spectrums. On component testing, probably the best procedure is to duplicate the loads at the critical points and run at testing speeds which are as fast as practicable.

Direction of Future Research—Helicopter engineers should be concentrating on learning how to define allowable stresses and design for long life in parts. Forthcoming transport helicopters will require essentially failure-free parts good for thousands of hours of unquestionable service. It won't be enough to aim at 1000-hr service life, as so many helicopter men now seem to be doing.

(Panel on Fatigue Research Applicable to Helicopters was held at SAE Annual Meeting, Detroit, Jan. 14, 1954. No written presentations are available.)

Six Ways to Cut Loss Of Material in Process

Based on paper by

D. C. FEHLEISEN

Engine Div., Fairchild Engine & Airplane Co.

SIX steps can be taken to control work in process to prevent floor shrinkage. These are:

1. Process material on individual shop orders, recording quantity of pieces in and out of each operation.
2. Post, record, and dispose of scrap as it occurs.
3. Write up "Material Lost in Process" forms for material lost in each operation.
4. Used fenced off "count center" areas for material storage and counting between non-consecutive operations. House inspectors and timekeepers can be located here.
5. Use statistical methods to sample overall count problem.
6. Centralize dispatching. Area dispatchers, in charge of count centers, report to overall shop dispatcher to police shrinkage.

These steps will give a fair indication of what is happening to material in process. They may reveal an inadequate supply of raw material being furnished to complete quantities specified on order, parts being used at final assembly that have not been cleared through detail inspection and stores, or hoarding of material for rainy-day work.

Inventory control should be determined by the inventory annual turnover rate. Accessory makers strive for 4.8 per annum, engine manufacturers for about 6 per annum.

Obsolete material carried in inventory can upset a financial statement. Production Control should list such materials, or material no longer in current use, for screening by Engineering and Sales. If it has no future value it should be disposed of. The remainder should be held in dead storage, reviewed monthly, and deflated in book value.

There is a definite trend to prevent sub-contractors from shipping in advance of schedule lest inventories be built up.

The need for expensive "insurance" inventories has been reduced by using open stockrooms in assembly areas. Assembly area dispatchers are charged

Production Control Panel Members . . .

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Panel Leader
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D. C. Fehleisen,
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Fairchild Engine & Airplane Co.

Jack Bethune,
Aircraft Gas Turbine Div.,
General Electric Co.

R. Gantz,
Aviation Gas Turbine Div.,
Westinghouse Electric Co.

A. C. Hartman, Jr.,
Air Associates, Inc.

John S. Mason,
Glenn L. Martin Co.

Milo McCammon,
Eclipse-Pioneer Div.,
Bendix Aviation Corp.

E. G. Nicholson,
Sperry Gyroscope Co.

T. A. Sandstrom,
Thompson Products, Inc.

with maintaining sufficient material to hold line production. An airframe manufacturer who has discontinued storerooms as such reports not only decreased inventories, but reduction in assembly shrinkage since the locks were taken off these areas.

(This article is based on the secretary's report of panel on Production Control held as part of the Production Forum at the SAE National Aeronautic Meeting, New York, April 12, 1954. It is available in full in multilithographed form together with reports of the other six panels at this Production Forum, as SP-309 from SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.)

Foreign Sports Cars Forcing U.S. Makers into Field

Based on paper by

H. R. MARTIN

General Motors Institute

FOREIGN sports car popularity in the United States is causing domestic automobile manufacturers to sit up and

take notice. The unique design features of these sports cars are gaining more recognition in the trade and by the public.

Since World War II, automobile producers have become aware that the American public is looking to Europe for its sports cars. Most popular are the MG and the Jaguar. In 1952, 26% of all imported cars were MGs, 11% were Jaguars. Both are light weight, well-balanced, cars with a top speed, acceleration, and cruising speed similar to standard automobiles. Their low center of gravity, positive controls, and excellent braking make them safe and easy to handle.

Other foreign sports cars, such as the Allard, Cisitalia, Ferrari, and Mercedes are popular in this country, but their limited production prices them out of the general market.

Some design features, such as overhead valves, four wheel independent suspension, front wheel drive and rear mounted engines have already been adopted by several European and American stock cars.

A few major companies have developed prototype sports models incorporating features pioneered in Europe or by amateur American sports car enthusiasts. Chevrolet has produced the plastic body Corvette and intends to put out 10,000 a year. Other American producers have similar plans to cash in on the sports car interest. (Paper, "The Sports Car In America" was the winner in the SAE Student Paper Contest, sponsored by the Mid-Michigan Section, May 1, 1953.)

SP-82 Procedures Prove Practical Aid

Based on paper by

D. B. McFADDEN
Humble Oil & Refining Co

and

F. M. JOBES
Ethyl Corp.

WHEN Texas changed its load weight regulations in 1951, raising the maximum GCW to 58,420 lb, Humble purchased 6000 gal transport trailers to take advantage of it. When these were used with the "standard" truck tractor, powered with a 386 cu in. engine, the performance was inferior in comparison with the same truck tractor in combination with the old 4800 gal trailer having a 48,000 lb GCW.

Seeking to improve performance, it was decided to use the information provided by SAE Special Publication No. 82 in predicted performance

studies. The following studies were made:

1—Effect on performance of increasing GCW from 48,000 to 58,000 lb. This showed an additional 14.2 hp required at 45 mph legal speed limit.

2—Effect on performance of increasing engine "net hp" either by means of increased compression ratio, or use of larger engines having increased "net hp" output. This was first studied in our "High CR" engine studies, but threads through most of our comparative performance studies, so no particular results will be cited.

3—Effect on performance of tractors in van service compared with transport service. This showed about 22 more engine "net hp" required for van service due to larger frontal area.

4—Effect of performance and operation of 5-speed transmissions used with single-speed or two-speed rear axles, by means of gearshift "gaps" and "overlaps." Improvements in gear ratios of 5-speed transmissions to eliminate excessive gaps and overlaps will result in improved performance and operation. Where excessive gaps are reduced to a more satisfactory size, the tendency to lug will be substantially reduced and better engine durability obtained.

5—Comparative performance of different makes and models, equipped with different transmissions and axles, and engines of varying net hp output, proved beneficial when considering specifications for purchase of tractors.

From these studies it was found that tractor engine horsepower specifications for satisfactory performance at specified governed rpm, when hauling a 58,400 lb GCW load, were as follows:

1. For transport service (8×8 ft frontal area)

- Gross engine horsepower, minimum—170
- Net engine horsepower, minimum—155

2. For van service (8×12.5 ft frontal area)

- Gross engine horsepower, minimum—190
- Net engine horsepower, minimum—175

3. For both transport and van service—same as for van.

Experience in service indicates satisfactory performance from these specifications and an ability to save time on long trips which can be used in practical manner to decrease transportation costs.

(Paper "The Use of SAE SP-82 Method to Predict the Performance of Transport & Van Tractor-Trailer Combinations" was presented at SAE Texas Gulf Coast Section, Houston, March 12, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

New Members Qualified

These applicants qualified for admission to the Society between August 10, 1954 and September 10, 1954. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Gordon Forster (A), Benjamin Arnold Harrison (M), Ferenc Pados (M), Percy Earl Walsh (M).

Baltimore Section

Gerald W. DeLoy (J).

Buffalo Section

D. McEwen (M).

Canadian Section

David C. Barber (A), Norman Andrew Kennedy (M), Henry James Mogg (A), A. Raymond Oliver (J), Ronald Douglas Parkinson (A).

Central Illinois Section

B. P. Bessert (J), Ralph Burnett Clark (M), O. C. Evans (A), Marvin Rosaa (M).

Chicago Section

R. L. Branchfield (M), Donald Lawrence Bryant (J), Leslie A. Dyke (M), Arthur W. Glass (M), Clinton R. Hummer (M), James A. Maguire (J), John E. Mahoney (M), Glen Ramsey (M), Donald James Sutherland (A), Bruce W. Wadman (J), A. G. Weston (M).

Cincinnati Section

Robert T. McSorley (A).

Cleveland Section

Darold Arthur Augustin (M), Frederick F. Franklin (M), James Joseph Grimshaw (A), Melvin P. Hershey (M), Lee M. Kettering (M), Robert S. Morrison (A), John R. O'Donnell (J), George E. Payne (J), John A. Walko (J).

Colorado Group

Charles Thomas Culbertson (A), Clay W. Dintaman (A).

Dayton Section

Frank M. Barnhill (M).

Please turn page

New Members Qualified

continued

Detroit Section

John H. Allen (M), William J. Athanson (A), Vincent P. Burns (M), Bertil Bernard Cederleaf (M), Edward James Paul Cunningham (J), Gregory W. Dean (M), Eugene B. Delaney (A), William A. Delger (M), Douglas V. Doane (M), Allen R. Elliott (A), Ralph H. Eshelman (A), Calvin S. Falk (J), George William Findley (M), L. E. Fleuelling (M), William George (J), William W. Glendinning (A), Alton N. Gray (M), George K. Hammond (M), Jack Allan Kerns (A), Edwin Roger Kirk (M), John W. Lester (J), Robert Kurtz Louden (J), Richard Joseph Mandle (J), Arne M. Mars (M), Rene C. McPherson (J), Frederick Wendell Phillips (M), Julius A. Riedl (M), Ormund I. Rugg (M), Vance L. Shields (A), Helge B. Sorensen (M), Irvin Stewart (A), Marcel Toupin (A), George F. Wahl (M), William M. Wood (M), Alex P. Zukowski (J).

Indiana Section

Gene P. Davis (M), Roger A. Dull (M), O. F. Gamillscheg (M), Frederick E. Jones (M), C. J. Loveless (M), Otakar P. Prachar (M).

Kansas City Section

Isaac Herbert Hoover (J), Arnold R. Peterson (A), James D. Roden (A), Ray R. West (A).

Metropolitan Section

Robert Wallace Blake (M), Charles B. Bleasby Jr. (M), Anthony John Carrano (M), Stephen J. Gensinger (A), Albert L. Hanson (A), Ernest A. Linke (M), James S. Lunn (M), William Kennett McKittrick (M), Charles I. Morton (A), Edward M. Powers (M), Bernd Richelmann (J), Firmin E. Rondepierre (M), J. F. Sauer (A), Dallas B. Sherman (M), Walter Stubbs (M).

Mid-Continent Section

B. M. Salyer Jr. (M).

Mid-Michigan Section

Warren R. Cook (M), Robert William Metzger (J), Robert P. Rohde (J).

Milwaukee Section

Albert Raymond Behnke (M), E. Jack Borisch (J), Robert G. Jensen

New Members Qualified

continued

(J), Charles R. Peifer (M), Howard J. Pike (J), Eugene John Shermeister (A).

Mohawk-Hudson Group

Harold E. Hilty (A), John Bob James (J).

Montreal Section

Nicholas Roehrberg (M).

New England Section

Howard J. Baier (J), Richard H. Frost (A), Frederick M. MacDonald (M), Gerhard Reethof (M), John P. Turner Jr. (M), Harold E. Wright (M).

Northwest Section

Ellis C. Hendrickson (M), Edw. P. Marilley Jr. (A), John M. Rendle (J).

Northern California Section

Meridith M. Millward (A), Brooks Walker (M).

Philadelphia Section

Edward Francis Allwein (J), Donald M. Davis (M), Robert E. Drake (M), Dr. Arthur B. Hersberger (M), Charles D. Hoskins (M), William Ibsen Jr. (J), Robert H. Thena (M).

Pittsburgh Section

Charles A. Cashion (A), William H. Ewing (A), Earl L. Kendrick (J).

St. Louis Section

Jerome B. Wegmann (A).

San Diego Section

Walter Jordan (A), H. K. Lyon (M), John Richard Payne (A), George Howard Schwab Jr. (M).

Southern California Section

Albert B. Bishop (M), Howell E. Bomar (A), John H. Boner (M), Cleo R. Davidson (A), Jack W. Galvin (A), Bernard R. Heymann (M), Thomas J. Rollins (M), Angus McNeill Saunders (A), L. Elliot Weir (A).

New Members Qualified

continued

Southern New England Section

Paul Eugene Brouthers (A), Frank C. Codola (J), Robert Raufeisen (J).

Syracuse Section

2nd Lt. William Howard Dunham (J).

Texas Section

Fred N. Dickerman (M), Marvin G. Starr (M).

Texas Gulf Coast Section

M. W. Frack (M), Norvel Killion (M).

Twin City Section

Robert Donald Atkins (M), James Lovaas (M).

Virginia Section

Forest C. Anderson (A), Joseph P. Crenshaw (A), Calvin W. Kersey (M), Thomas L. Sharp (M).

Washington Section

Nicholas P. Oglesby (M), Stewart Scott-Hall (M), Lt. Col. Charles Edward Septfonds Jr. (M).

Western Michigan Section

Lloyd Masser (M).

Outside Section Territory

William Hobart Austry (M), Philip R. Bunnelle (J), Gordon Ness Carlson (J), Richard S. Clement (J), Lt. (jg) Daniel C. Hughes Jr. (J), William Luthi (A), Robert H. Meier (M), Walter J. Piper (M), Hans W. Sack (J), John Roy Smith Jr., (J), Russell Bell Smith (M), Laurence Elder Snodgrass (M), Wagn Trautner (M), Col. William P. Withers (M).

Foreign

Pierre L. Gousseland (M), France; Itsuo Kagehira (M), Japan; Nilal Shashi Prabhakar Naidu (J), United Kingdom; Colin John Prebble (J), England; Robert G. Yeamans (M), Italy.

Applications Received

The applications for membership received between August 10, 1954 and September 10, 1954 are listed below.

Alberta Group

John Graham Bruce.

Atlanta Group

Albert D. Brown, Charles H. Dolson, Daniel J. Haughton, John M. Malone, James H. Maxwell, Paul A. Young.

Baltimore Section

Arthur A. Baxter, Frederick Charles Ziemer, Jr.

British Columbia Section

Gordon Stanley Boyle, Neville Mitchell.

Buffalo Section

Lloyd Edward Gomez.

Canadian Section

Ernest R. Chown, Frederick Allan Knight, Alexander W. Peev, William Wesley Stewart.

Central Illinois Section

Richard Henry Axness, Parry Barnes, Jr., James William Crane, Raymond N. Erkkila, Harold D. Harms, John A. Immel, Robert E. Moore, James R. Sebern, Neil Swartzhaugh.

Chicago Section

Robert C. Allison, Charles Frederick Bacon, Eugene L. Boyce, Donald F. Domnick, Roy O. Erickson, Raymond Louis Rubey, Oliver Waller Scheflow, Raymond Randolph Snyder, Robert Daryl Straszheim, Kenneth E. Whiteley.

Cincinnati Section

Henry A. Ezyk, Leonard E. Good, Raymond L. Grismer, Jr., Alfred Gregory Orillion, William Robinson Timmer, Henry A. Torgersen, J. Duane Wethe.

Cleveland Section

Barton C. Conant, Torris W. Crooks, Wilber Gordon Dallas, Jr., Charles L. Driscoll, Russel Philip Gantos, L. Abbott Leissler, Alvin R. Morris, Sherman Rinard, Clarence Edward Youngman.

Applications Received

continued

Dayton Section

Melvin S. Lantz, Jack Wittcamp.

Detroit Section

Waldewar H. Adams, Russell A. Ash, James E. Bair, Wallace E. Beaber, Michael C. Berkey, William T. Birge, Paul J. Blinkilde, Paul D. Blystone, Joseph S. Bull, Forest O. Byrd, John T. Camden, Raymond Morris Cole, William Thaw Collins, Jr., Joseph Benjamin Conte, Howard L. Croswhite, Joseph Ricardo deMartino, John F. Devine, Robert A. Dezelick, Douglas D. Donkin, Robert E. Gibson, Richard Harold Hafer, Robert W. Hancock, Olen W. Hart, William O. Heyn, Clayton Antone Huben, Paul J. Ignatowski, Roger C. Jaqua, Chester L. Jones, Edgar D. Jones, Evan L. Jones, Harold Burton Jones, Alfred S. Jossi, Charles Edward Juran, Theodore Edward Kashmerick, M. L. Katke, Richard B. Kazmier, John W. Keller, Robert P. Keller, E. Dudley Kress, Charles R. Lautz, Jr., George Raymond Lefevre, Horace H. Ligan, Jerry Paul Lindsay, I. David Long, Jr., Thomas L. McCarthy, Stanley H. Mick, Thomas Edward Miller, Donald D. Nelson, William F. Nunnold, Leonard Obrebski, Fred Onkalo, Jr., Richard M. Petersen, Donald J. Pulk, Donald Irwin Rohrbach, John Reynolds Secord, Ray Welch Sevakis, George A. Sparks, Anthony John Tocco, Thomas J. Walsh, Frederick B. Wiggins, Edward H. Bacon, C. J. Moody, Charles N. Tripp.

Indiana Section

Thomas John Baldauf, Raymond George Fischer, Henry K. Purnhagen, Albert E. Salatka, David K. Thomas, James Allen Williams.

Metropolitan Section

Thomas Aal, Jack Beech, Julian Phillip Berch, Joel Blatt, Gregory Joseph Brandewiede, Louis J. Campamelli, Jr., Douglas Campbell, Branch T. Dykes, Roy Ehnhuus, Constantino Formicola, Owen E. Gilligan, John E. Kruck, Roy Harold Lindenlaub, Nils H. Lou, Charles L. Meserve, Irving D. Press, Paul R. Rhinehart, Lyndel B. Schild, Kimball Joseph Scribner, John D. Smith, Paul A. Steidel, Ronald E. Trenkner, Charles Richard Williams, Paul J. Williams, Pedro S. Yujuico, Ralph J. Opre.

Mid-Continent Section

Jefferson Woolf Mitchell, Edmund O. Schroeder.

Please turn page

Applications Received

continued

Mid-Michigan Section

Harvey A. Barkley, Alfred Burton Carpenter, James M. Combest, Dominick Joseph DeFazio, Robert P. Forella, Edward Lloyd Kelly, Arthur T. Koster, William H. Lichty, Frank H. Walker, Hugh D. Wright.

Milwaukee Section

George B. Luhman, Jr., Lawrence J. Matthews, John E. Obernesser, Robert A. Panlener, Glenn E. Poehls, Lowell M. Schmidt, Donald J. Seaman, Jr., Zach Earl Taylor.

Montreal Section

Jack Peter Toronchuk.

New England Section

George E. Gardner, Duncan W. H. MacKinnon, Peter Caldwell Tappan.

Northern California Section

George U. Brumbaugh, Charles R. Coffey, Joseph Mednick, W. C. Mentzer, Arthur R. Miser.

Northwest Section

Jack Leonard Gregory, James Portugal.

Oregon Section

James P. Bates, James Joseph Hill.

Philadelphia Section

Wesley F. Carroll, Jr., Thomas Edward Cullins, Daniel J. Featherman, J. Garrett Forsythe, Jr., David Lantz Gamble, Herbert A. Magnus, John E. Morrow, Jr., Frederick Carl Schwartz, Jr., Isadore M. Scott.

Pittsburgh Section

Robert Aronstein, Allan H. Johnston, Jonathan T. Carriel, Edward Arthur Peterson, Robert M. Thurston.

St. Louis Section

John L. Bame, Frederick Ephraim Klarfeld, James J. Ryan, Jr., Louis Henry Winkler, Joseph Wiskirchen, Robert B. Young.

San Diego Section

Stuart N. Chamberlin, Roy F. Christensen, Charles E. Phillips, Robert Marlin Wright.

Southern California Section

Richard S. Bandy, John R. Bogue, Gordon L. Churchill, Howard John Feichtmann, William R. Frank, Alan M. Haire, Richard W. King, Paul D. Koger, Stanley J. Kukawka, John M. Lipscomb, Marvin Paul McCollum, Robert F. Moyer, Theodore C. Nark, Jr., Douglas P. Pedersen, Bernard L. Rice, Edwin Stear, Walter B. Stout, Clayton E. Wells, Forest M. Wilhite, Vernon R. Wills.

Southern New England Section

Edward W. Dwyer, David T. Feldman, James J. Ford, Henry J. Johnson, Jr., Saul Kushnick, Joseph G.

Applications Received

continued

Maceyka, Peter G. Meyers, Hugh McVeigh Perkins, Jr., Clyde Vernon Stahle, Jr., William R. Stoecker.

Syracuse Section

Edward C. Potter.

Texas Gulf Coast Section

Thomas P. Wood.

Texas Section

James O. Bean, Jr., Clarence Lee Curl, Frank Wilbur Davis, R. I. Michaelson, Lawrence J. Sullivan.

Twin City Section

Theron Wright.

Washington Section

Manuel Cebollero, Randall Goff, Theodore Sidney Moise III, Stirling S. Wilson.

Western Michigan Section

Andrew J. Kozlowski, Gerald Lauril Larsen, Ivan E. Parsons, Jr.

Wichita Section

Kenneth Wilton Rix.

Williamsport Group

Arthur L. Altemose, Jr.

Outside of Section Territory

Edward C. Erickson, Fil L. Fina, Jr., Robert G. Friedman, Wayne Alan Hahne, C. E. Hoover, Albert Joseph Impink, Jr., Ralph K. Knuefener, John Stephen Patin, Clayton A. Palosaari, Donald Hooper Poston, Robert W. Rosselle, George W. Smith, Jr., Clyde S. Stearley, William A. Trace, Francis Xavier Tuoti, Earl Eugene Wellborn, Thomas Gregory Wier, Alton M. Williamson, H. Cecil Wolsey.

Foreign

K. S. Balakrishnan, England; Arthur Robert Burton, Australia; Herbert George Freeston, England; Rodrigo C. Fuentes, Colombia, S. A.; George Kruase, Switzerland; Penmetcha Somaraju, India.


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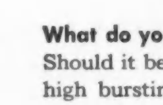

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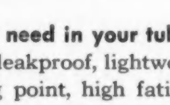
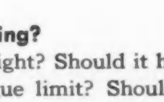
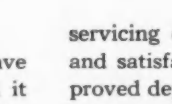


continuously rolled twice around laterally into a tube of uniform thickness,



and passed through a furnace. Copper coating fuses with steel. Result . . .



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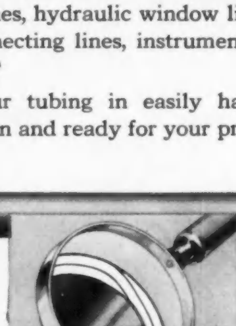

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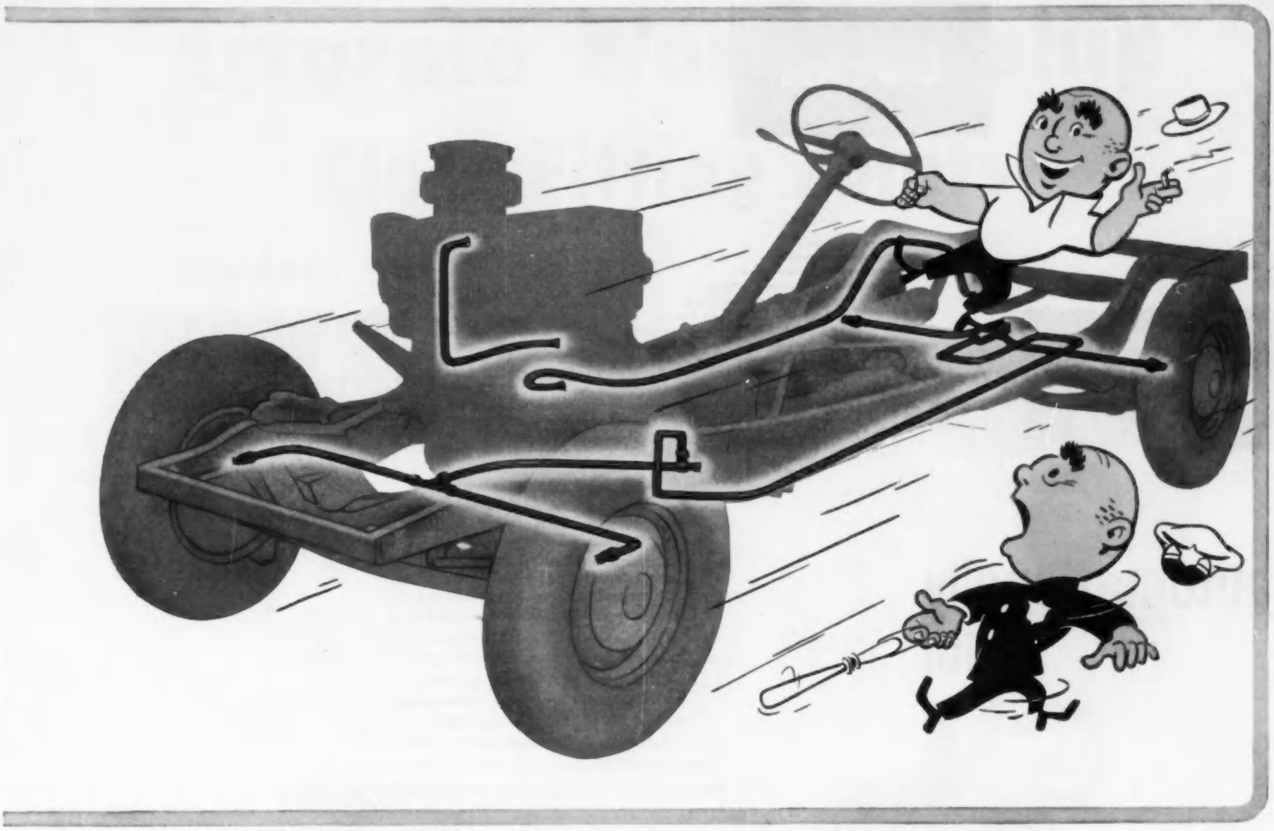

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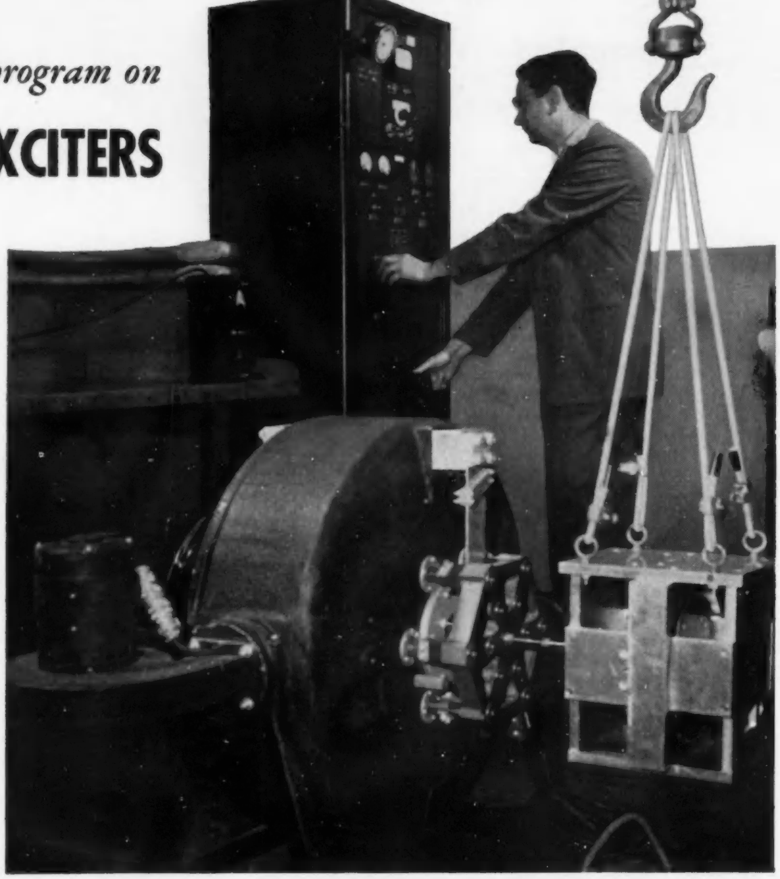

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Ray Carter

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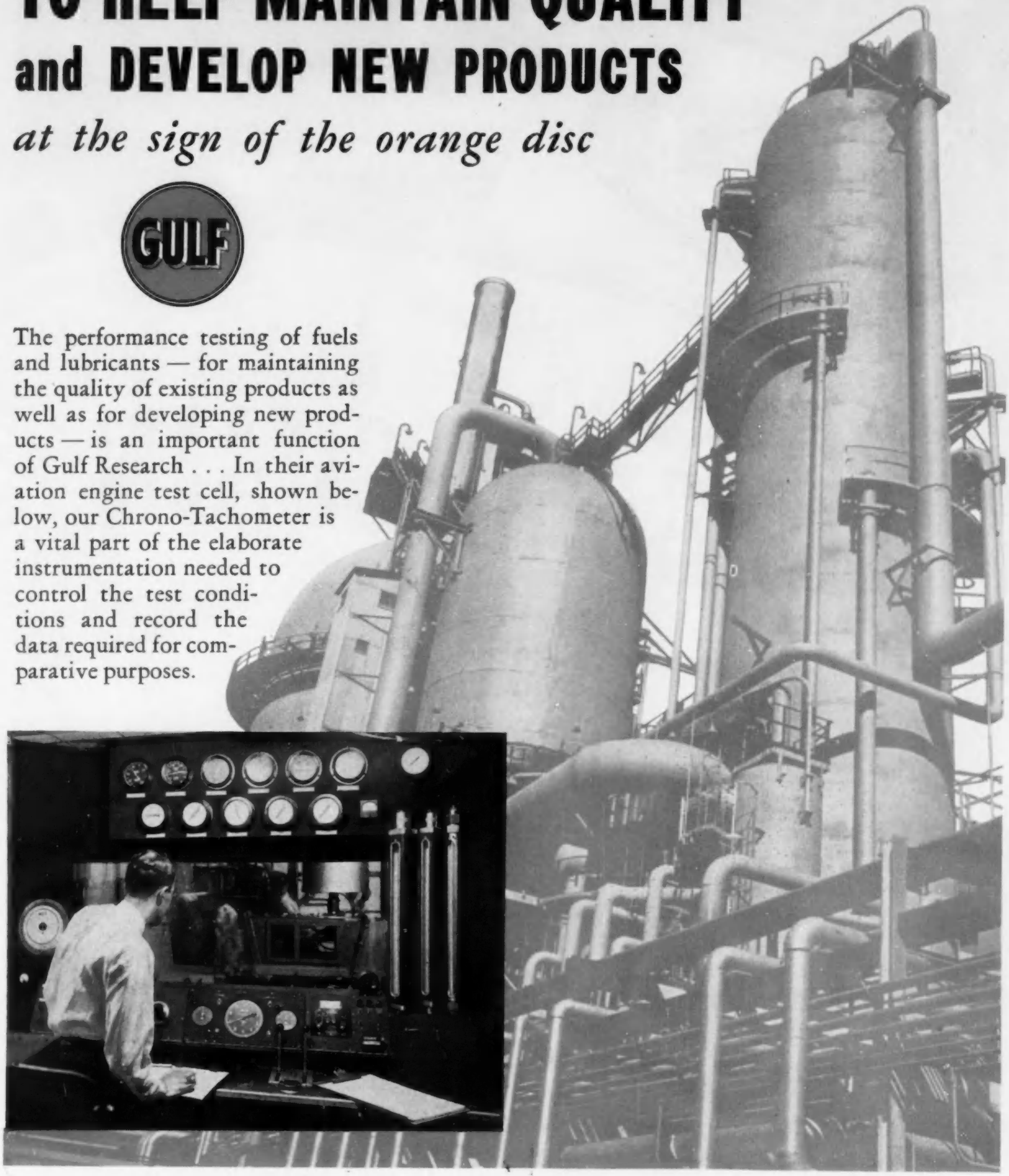

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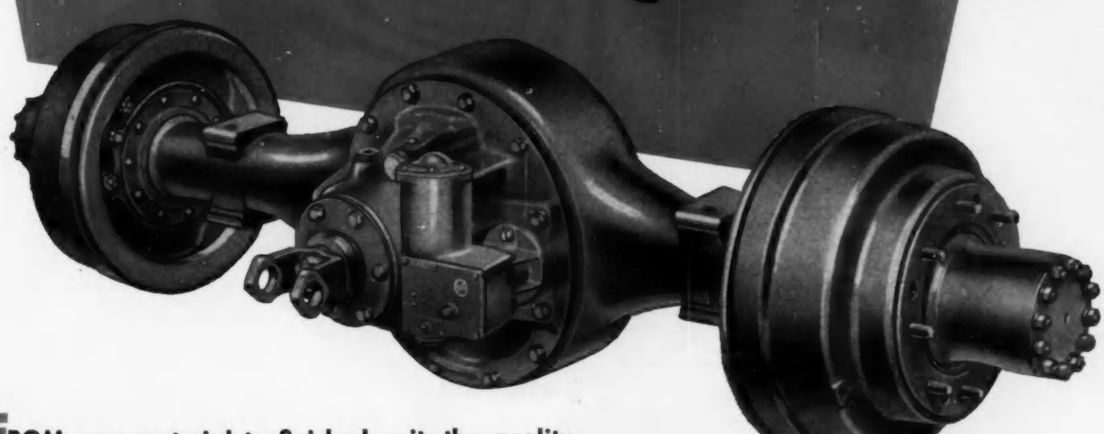

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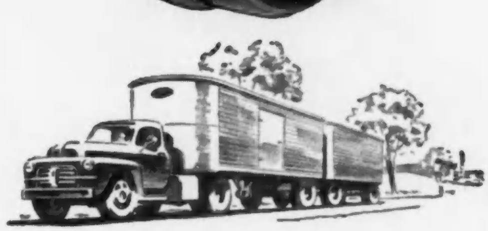

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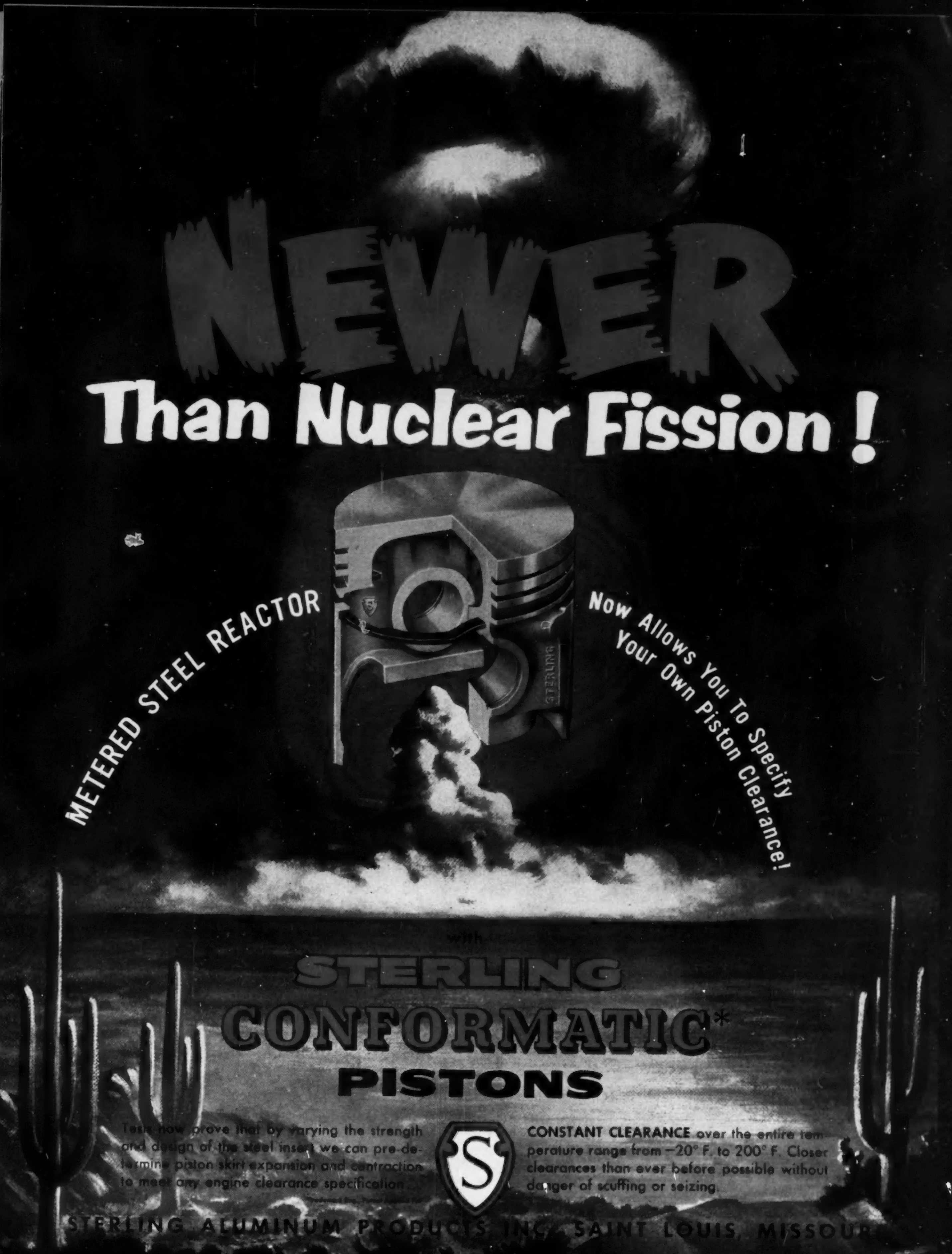

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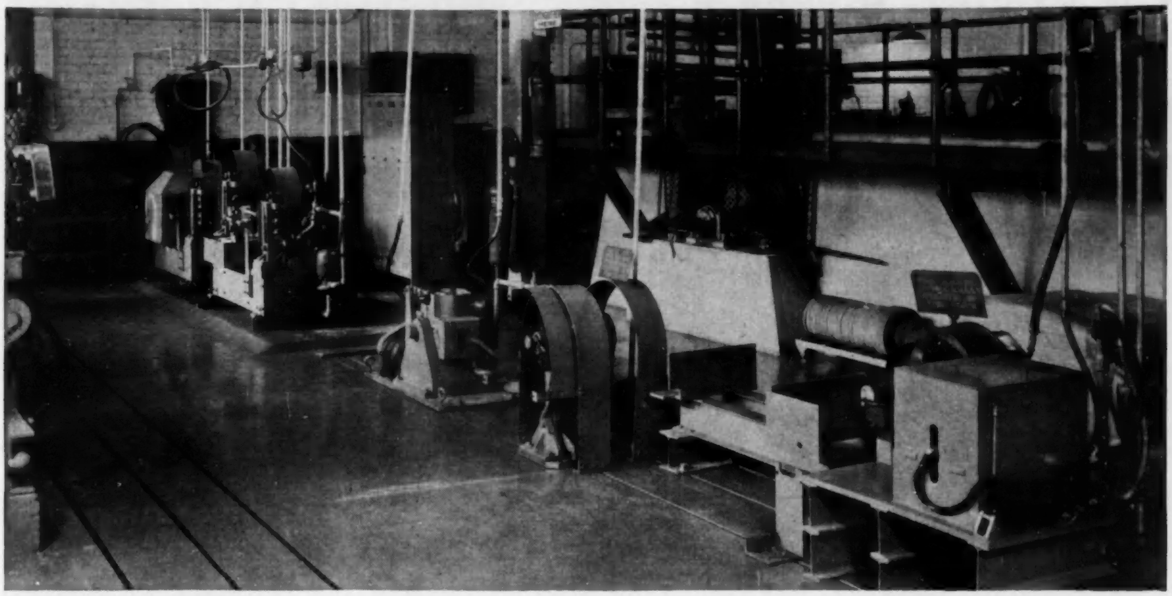
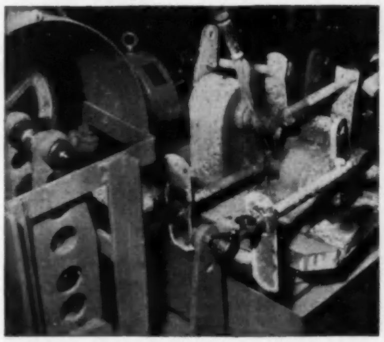
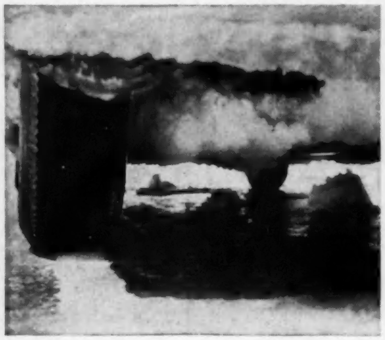
This is a Modern Torture Chamber



THOMPSON MAINTAINS THIS "TORTURE CHAMBER" in their Detroit laboratories to "performance-test" steering-linkage units under the most extreme conditions . . . tests that reveal the slightest imperfection.

Every one of these machines shown above faithfully duplicates difficult road conditions: gritty mud . . . dirty water . . . grinding friction . . . and jarring impacts, as frequently as ten 500-pound blows *per second!*





DOUBLE-Tested—Week after week, 24 hours a day, extra-severe punishment is dealt out to Thompson's experimental and standard tie rods, sockets, center links and drag links. In addition to this rigorous testing in Thompson's Detroit laboratories, these parts undergo furthur tests in standard-model cars out on the open road...not only on average highways but also on rutty, muddy back roads as well.

They MUST Be Right—Nothing less than perfectly-engineered parts, made of the finest metals, can survive these grueling tests which Thompson sets up in a constant search for *improvement*... in materials, in performance, in manufacturing procedures. New materials, new processes and new designs are all subjected to these rigid Performance Tests... and always under the most extreme conditions.

The Results?—These exacting tests . . . followed by periodic skilled analyses by experienced Thompson engineers . . . result in the finest possible linkage systems for America's cars, trucks, buses and tractors.

If you have a steering linkage problem, just write or phone Thompson Products, Michigan Plant, 7881 Conant Avenue, Detroit 11, Michigan, WA 1-5010.

You can count on Thompson Products

MICHIGAN PLANT: • DETROIT • FRUITPORT • PORTLAND

CLARK'S HYDRATORK* DRIVE CARLOADER*

The revolutionary HYDRATORK DRIVE lift truck is now available in Clark's 3000-5000 lb. Carloader. The new clutchless, torque converter transmission has already won many friends among users of Clark's 6000-7000 lb. Utilitrucs. The basic benefits of this Clark-built transmission are:

1. Lower cost: no gear clash, no clutch problems, excellent serviceability.

2. More power: faster, smoother get-away, better gradability.

3. Less driver fatigue: finger-tip direction control, no clutching or shifting.

The free booklet shows detailed disassembled views of the HYDRATORK DRIVE, explains how it works. Clip the coupon to your company letterhead and we'll send it to you.

CLARK EQUIPMENT

Industrial Truck Division · CLARK EQUIPMENT COMPANY · Battle Creek, Michigan

☐ Send free HYDRATORK DRIVE booklet

Name____________________ Firm____________________

Address____________________ City____________ Zone____ State_________

FROM THE ENGINEERING
A REVOLUTIONARY NEW

For trucks, trailers, hoists, tractors, harvesters, cranes, buses,

Pre-proved in "Torture Tests"

Here's where TDA brakes are run through exhaustive tests on brake dynamometers in the world's most exacting "Torture Chamber." New materials and design features are constantly being tested and developed for use in every type of product. Also, field tests are performed on all types of brake applications under every conceivable operating condition.

Another Spicer "FIRST"...
A REAL THREAT
TO JOINT LUBRICATION
HERE

Improved Universal Joint Seal!

NEW TYPE OF BEARING SEAL ASSURES LONGER, BETTER, MORE ECONOMICAL UNIVERSAL JOINT PERFORMANCE UNDER ALL TYPES OF ROAD CONDITIONS

Mud . . . sand . . . dust . . . water—these are ever-present factors of destruction that have always put a heavy drain on universal joint life.

Now Spicer . . . famous pioneer in universal joint design . . . has developed a new lip-type seal that protects Spicer joint bearings under all operating conditions.

This new Spicer synthetic rubber seal has been tested and proved in military and commercial truck use for over three years. Performance records attest the ability of the seal to prevent foreign matter from contaminating bearing lubricants. And that this seal will stand up much longer than any other type previously used.

Result: Less universal joint bearing wear. Fewer repairs and replacements. Less "down" time.

The exclusive new Spicer seal is available only in Spicer Universal Joints for original equipment, and in Spicer Universal Joint replacement kits for servicing older vehicles.

PLENTY OF JOINT LUBRICATION PROTECTION HERE

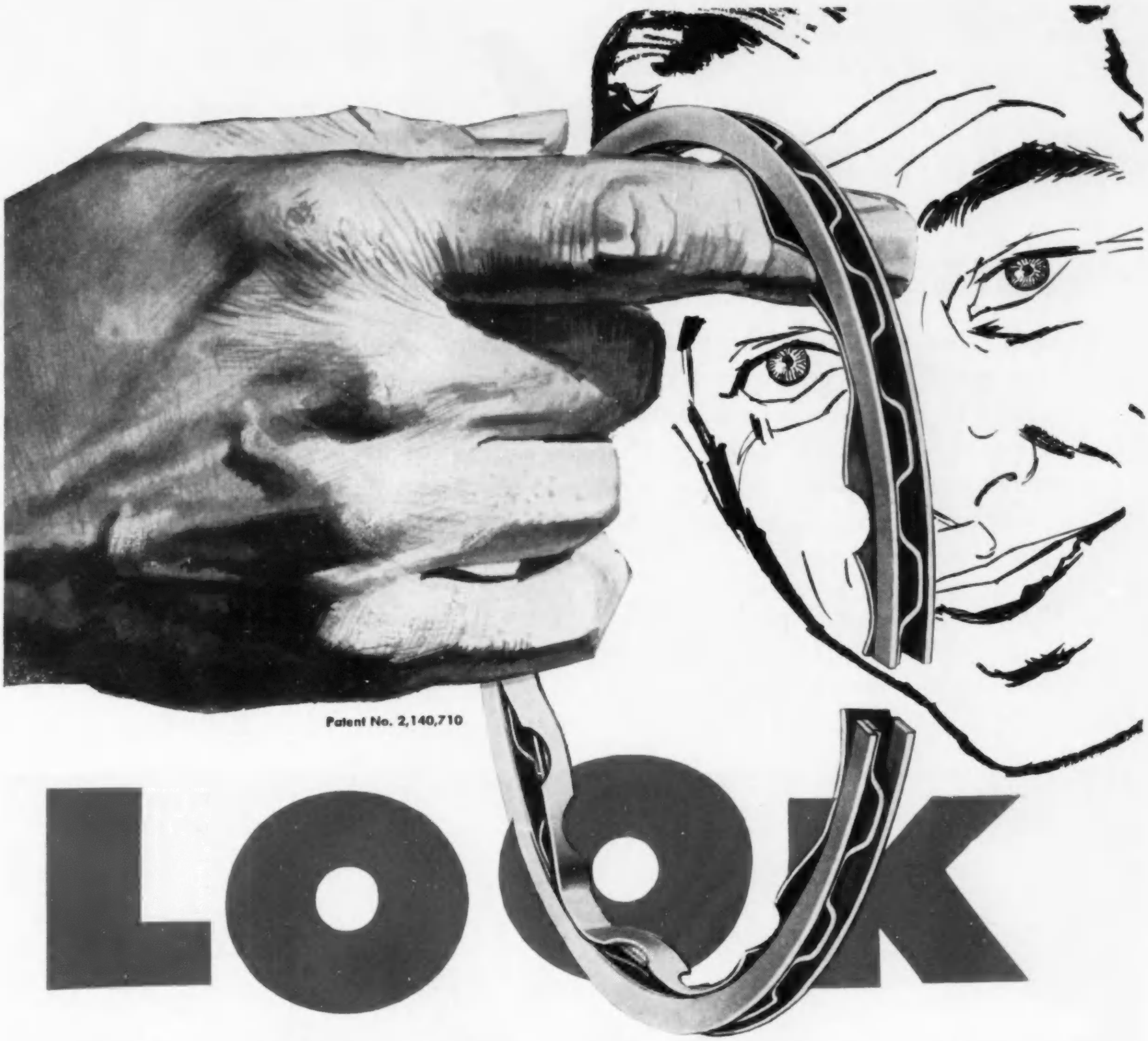
DANA CORPORATION

TOLEDO 1, OHIO

50 YEARS OF **Spicer** SERVICE

SPICER PRODUCTS:

TRANSMISSIONS	POWER TAKE-OFFS
UNIVERSAL JOINTS	POWER TAKE-OFF JOINTS
PROPELLER SHAFTS	RAIL CAR DRIVES
AXLES	RAILWAY GENERATOR DRIVES
TORQUE CONVERTERS	STAMPINGS
GEAR BOXES	SPICER and AUBURN CLUTCHES



it handles like a one-piece ring!

NEW MUSKEGON

"UNITIZED"

CHROME PLATED OIL RINGS

MUSKEGON Piston Rings

MUSKEGON PISTON RING CO.
MUSKEGON, MICHIGAN
PLANTS AT MUSKEGON AND SPARTA

Since 1921... The engine builders' source!

You see at a glance that it's something new, different, better—a multiple-piece oil ring that *handles* like a one-piece ring!

But take a *good* look. See for yourself how Muskegon's patented *Unitizing* process holds the pieces together in the right order for quick, easy installation. Then, in the first rush of hot oil, as the engine starts to run, the special adhesive dissolves completely and leaves the parts of the ring free to function independently of each other.

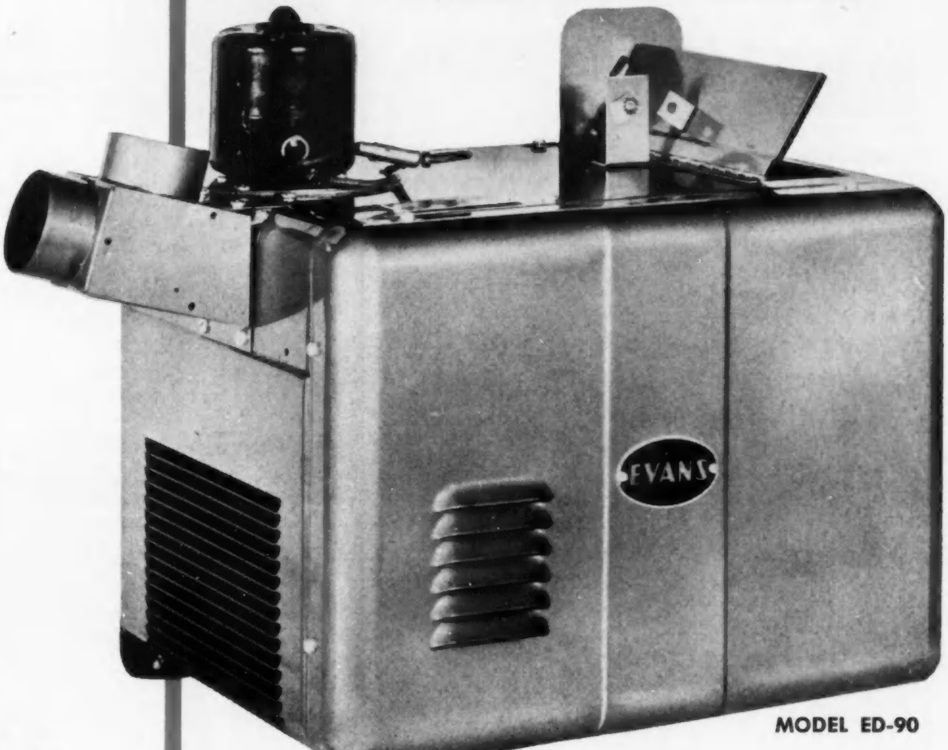
Test Muskegon's CSR-200 rings in your own engines, in your own laboratory. See how the chrome plated rails reduce ring wear and bore wear, scuffing and friction—see how these rings keep the engine new longer and increase oil economy.

And your eyes will be wide with amazement when you learn that the price is just *half* that of chrome plated cast iron oil rings! Write us today.

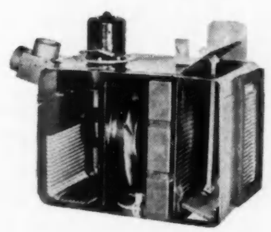
DETROIT OFFICE: 521 New Center Bldg., Telephone Trinity 2-2113

a new heater defroster

specially designed by EVANS for large truck cabs



MODEL ED-90



Removing front cover exposes all elements for easy servicing. Note the exclusive Evanair 9" Die-cast fan, the interlocked dampers for mixing recirculated and fresh air, the extra thick 2" core, the built-in high pressure blower with extra large motor and the over-all heavy duty construction.

- 100% fresh air or mixed with recirculated air as driver desires
- Powerful built-in pressure type defroster blower 72.2 CFM of hot air at windshield
- Controlled summer comfort, 100% fresh air with water shut off
- Balanced heat distribution to cab floor, driver and helper
- Pressurized heating and ventilating when set for all fresh air
- Plus all these Evans standard features: Distinctive Styling, Compact Design, Modern Appearance, Built-in Durability, High Efficiency, Engineered-to-match motors, fans and cores, Easily Accessible Components, Full-Year (or 50,000 mile) Warranty.

For further information on Evans heaters or expert engineering advice on any truck or bus heating and ventilating problem, write Evans Products Company, Dept. Z-10, Plymouth, Michigan.

EVANS ... *BALANCED HEATING & VENTILATING SYSTEMS FOR EVERY TRUCK AND BUS* ... EVANS ®

REGIONAL REPRESENTATIVES: CLEVELAND, FRANK A. CHASE • CHICAGO, R. A. LENNOX CO., INC. • DETROIT, CHAS F. MURRAY SALES CO. • ALLENTOWN, PA., P. R. WEIDNER

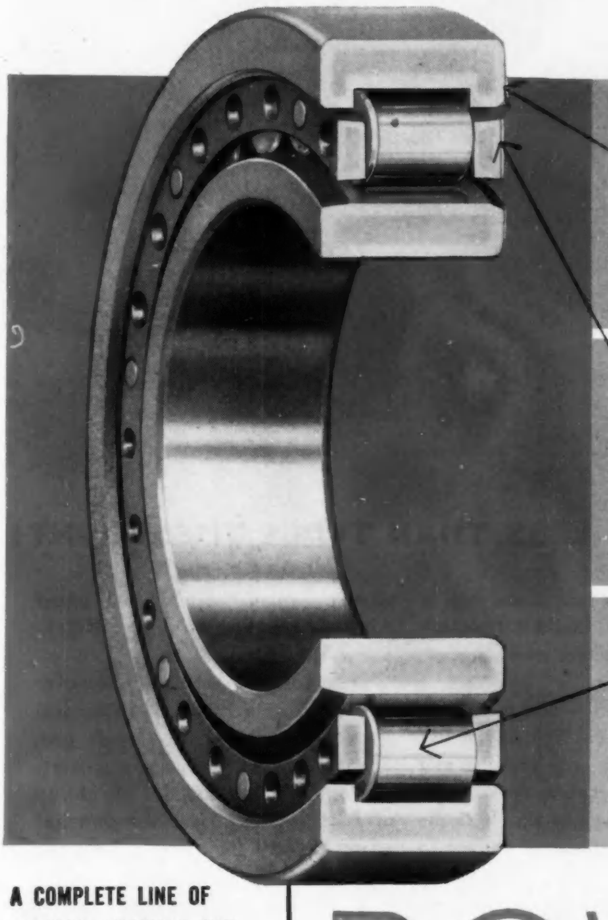
Here's why BOWER straight roller bearings can carry maximum loads—with less maintenance!

The important design features of Bower straight roller bearings shown on this page are just a few of the reasons why these bearings will operate efficiently and economically in your product. Consider these facts, too. Bower straight roller bearings incorporate highest quality materials and workmanship. They have proved themselves capable of standing up day in and day out under maximum loads—with little or no maintenance.

In fact, this is the reason why Bower straight roller bearings are used extensively by leading manufacturers in such fields as automotive, earthmoving, farm equipment and machine tool.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the blueprint stage.

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN



- *TWO-LIP RACE INCREASES RIGIDITY.* These two shoulders, made parallel, are integral with the outer race. This provides a more rigid, durable construction. Rollers are kept in proper alignment at all times.
- *COMPOSITE STEEL CAGE DOES NOT CONTACT ROLLERS DURING NORMAL OPERATION,* thereby allowing free movement of the rollers between the races. Projections on the inner faces of the rings engage indentations on the roller ends prevent'ng the rollers from dropping out of position when the separable race is removed.
- *PRECISION-BUILT ROLLERS AND RACES ARE MADE TO SUPPORT MAXIMUM RADIAL LOADS.* Only the highest grade steel-alloy is used, and rollers and races are precision ground to give quieter, smoother operation. Running clearance is built in at the time of manufacture.

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS FOR EVERY FIELD OF TRANSPORTATION AND INDUSTRY

BOWER ROLLER BEARINGS

SPHERO HONED

FOR TODAY'S *Push Button* CONVENIENCES—

AMERICAN BOSCH
SMALL ELECTRIC MOTORS

to power—

WINDSHILD WIPERS • SEATS • TOPS • HOODS • WINDOWS • VENTILATORS • STARTERS • HEATERS • TRANSMISSION AND AXLE MECHANISMS

Well built, with characteristic AMERICAN BOSCH precision quality, these high-torque small Motors are sturdy, quiet, powerful and dependable. Just a few of the good reasons they are already in wide use as original equipment. If you have one or a number of small motor requirements in your designs, put the problem up to American Bosch, Springfield 7, Mass.

AMERICAN BOSCH

...and Always to Your Exact Specifications!

Western Felts are highly versatile! That's one of their tremendous advantages wherever you can use a felt component to help the performance of your product. We start with the very picking and carding of the millions of tiny wool fibres, with every process in our plant under our complete control!

Western Felts are made soft and springy, dense and hard, or of any of the unlimited degrees of density in between. They are conditioned for the exact jobs they are to perform, right down to the precision cutting to extremely close tolerances. Especially in the more dense consistencies, tolerances often are as close as a few-thousandths of an inch!

Wear, age and weather do not affect Western Felt parts. They deaden sound, seal against dust, greases and oils, or they are made to absorb and feed oil when used for lubrication...*exactly* as you wish. Western Felt parts can be chemically treated for hardness, waterproofing, mothproofing, oil retention, abrasion resistance...or greater tensile strength.

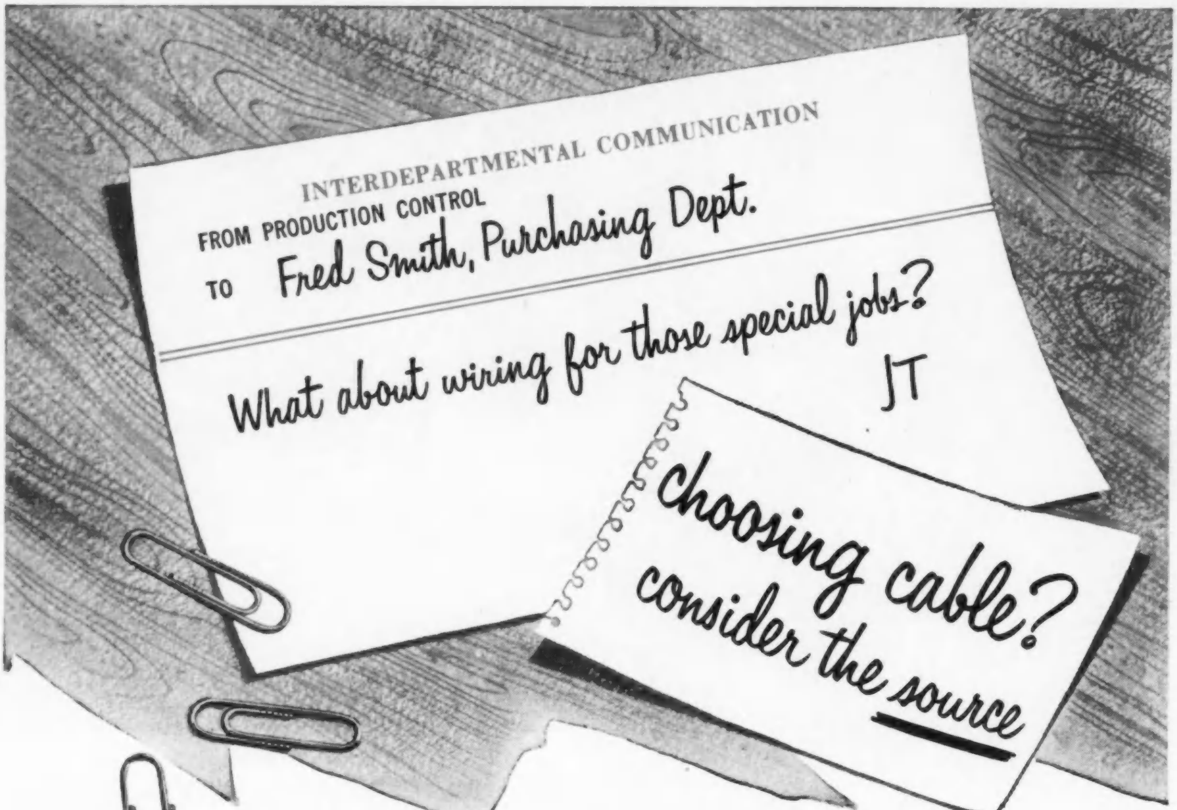
Western Felt components will help solve many of your problems. You are invited to consult with our engineers.

WESTERN Felt WORKS

4021-4139 W. Ogden Ave., Chicago 23, Illinois
Branch Offices in Principal Cities

TRADE MARK

MANUFACTURERS AND CUTTERS OF WOOL FELT



Many a manufacturer has chosen Packard cable and wiring assemblies solely because of Packard's uniform high quality—and has been pleasantly surprised to receive important *extra advantages*. For Packard provides experienced engineering counsel, production capacity sufficient for any need, and assured on-time delivery . . . and often it is intangibles such as these that help keep your production lines going.

Consider Packard as a source

The widespread use of Packard cable and wiring assemblies, by America's foremost automotive, aviation and appliance manufacturers, is your assurance of high quality. And, because Packard is equipped to turn out 7,000,000 feet of finished cable and 800,000 wiring assemblies *daily*, you can depend on unfailing delivery. In addition, Packard's large staff of engineers is ready to serve you at any time. Call on them—preferably while your new product or model is still on the drafting board. Their long experience in designing and fabricating cable and wiring assemblies can well result in important savings to you.

Packard

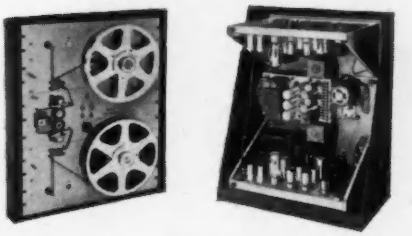
REG. U.S. PAT. OFF.
TRADE MARK

Packard Electric Division • General Motors Corporation • Warren, Ohio

AVIATION, AUTOMOTIVE AND APPLIANCE WIRING

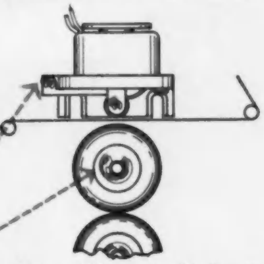
30 Waldes Truarc Rings Save Space and Time... Simplify Assembly and Disassembly

Potter's New Digital Magnetic Tape Handler

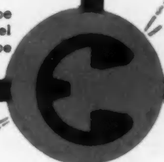


■ Prime requirements: fast starts, fast stops, fast tape speeds, great accuracy. Using Truarc rings, this new model starts and stops the tape within 5 milliseconds, has tape speeds up to 60 inches per second.

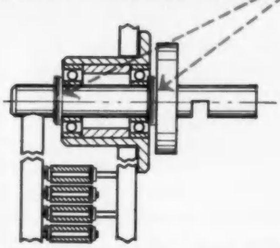
Solenoid Mount and Capstan Assembly



■ Miniature Truarc E-Rings on .040 diameter shaft and on continuously running capstans eliminate projecting bolts and screws. Rings permit rapid assembly and disassembly, fast replacement of worn rubber capstans.

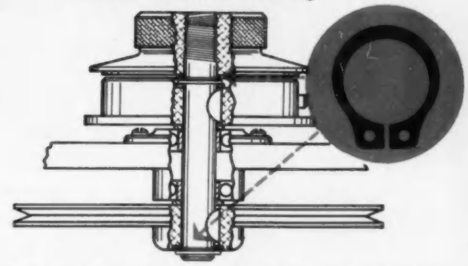


Tension Shaft Assembly



■ Truarc E-Rings snap quickly into place, act as shoulders for the ball bearings with a minimum of friction. Additional Truarc Rings are used as spacers on shafts, can be located accurately to extremely close tolerances.

Reel Shaft Assembly



■ Truarc Standard Rings (Series 5100) hold the reel shaft assembly firmly in place and permit the use of quick-lock hubs so that the reel tapes can be changed in seconds as they are finished.

Potter Instrument Company, Inc., of Great Neck, L. I., uses 30 Waldes Truarc Retaining Rings in their new Model 902 High Speed Digital Magnetic Tape Handler. In addition to solving a variety of fastening problems, Truarc Rings facilitate the rapid acceleration and fast stopping needed in these machines.

Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better, more economical job. Truarc Rings are precision engineered, quick and easy to assemble and disassemble. They save time and increase operating efficiency.

Find out what Waldes Truarc Retaining Rings can do for you, toward saving costs and improving your product. Send your blueprints to Waldes Truarc Engineers for individual attention without obligation.

For precision internal grooving and undercutting ... Waldes Truarc Grooving Tool!

SEND FOR NEW CATALOG

WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,948; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,509,081 AND OTHER PATENTS PENDING

SA 106

Waldes Kohinoor, Inc., 47-16 Austel Pl., L. I. C. 1, N.Y.

Please send me the new Waldes Truarc Retaining Ring catalog.

(Please print)

Name ....

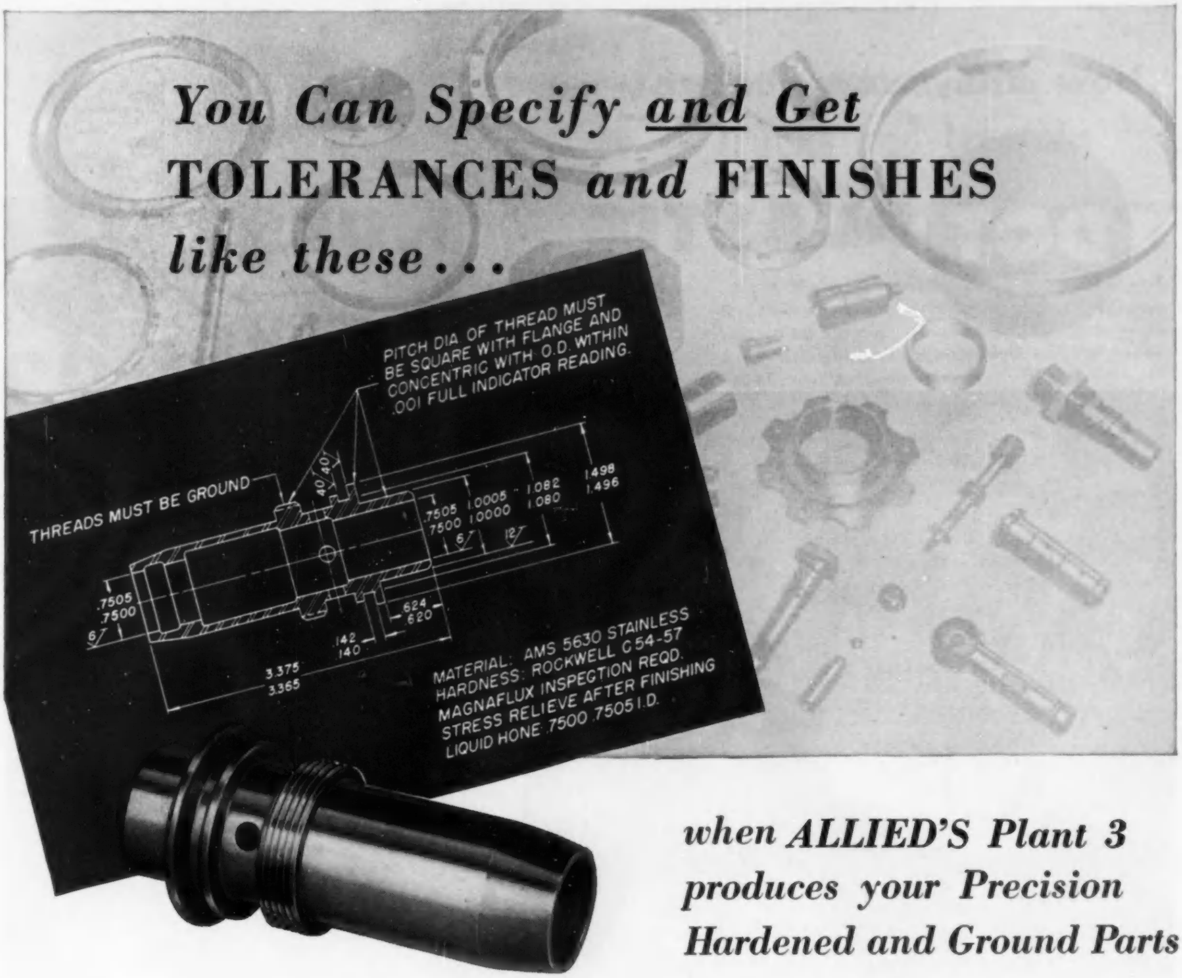
Title ....

Company ....

Business Address ....

City .... *Zone* .... *State* ....

You Can Specify ***and*** ***Get*** **TOLERANCES** *and* **FINISHES** *like these . . .*



when ALLIED'S Plant 3 produces your Precision Hardened and Ground Parts

Other Allied Products

SPECIAL COLD FORGED PARTS • STANDARD CAP SCREWS • SHEET METAL DIES PRODUCED IN IRON, ALLITE (ZINC ALLOY) AND PLASTIC • R-B INTERCHANGEABLE PUNCHES AND DIES

An unusual example? Not at all, for it is day-in and day-out procedure at Allied's Plant 3 to produce parts held to extremely close tolerances . . . with fine surface finishes . . . meeting rigid requirements for squareness and concentricity . . . and heat treated by the most accurately controlled methods.

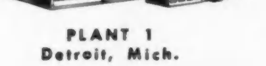
Regardless of how many or what type operations are called for to produce your precision parts, Allied's Plant 3 has every facility—and the proven ability—to perform these operations . . . quickly . . . economically . . . and to your exact specifications.

A New 16-Page Brochure describes and pictures in detail the facilities of Plant 3, where Allied produces precision hardened and ground parts. Included is a complete listing of all equipment in use. A copy will be sent you immediately upon request—without obligation, of course.

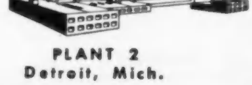
PRECISION • EXPERIENCE • DEPENDABILITY
ALLIED PRODUCTS CORPORATION

ALLIED PRODUCTS CORPORATION

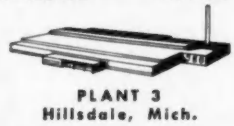
DEPT. D-20 12643 BURT ROAD DETROIT 23, MICHIGAN



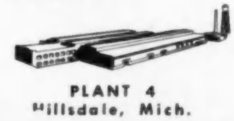
PLANT 1
Detroit, Mich.



PLANT 2
Detroit, Mich.



PLANT 3
Hillsdale, Mich.



PLANT 4
Hillsdale, Mich.

You get balanced performance

from every

TURQUOISE PENCIL

thanks to

100% "Electronic Graphite"

Even the super-soft 6B sharpens perfectly and gives you ample point strength for vigorous black strokes. The whole range of 17 degrees of TURQUOISE is decisively superior in point strength to comparable degrees of other drawing pencils.

Unmatched smoothness in all degrees is the sure result of the extreme particle fineness to which its 100% "Electronic" Graphite is reduced in Eagle's patented, *exclusive* Attrition Mill.

Blackness is appreciably enhanced because thousands more of the super-fine "Electronic" graphite particles are deposited at every stroke on the paper in *denser lines that reproduce to perfection.*

Longer wear is inherent because 100% "Electronic" graphite and super-refined clay binder are combined at white heat into the most closely knit, even-wearing ceramic structure known in pencil leads.

SEND FOR FREE SAMPLE, mentioning this magazine and the grade of pencil you want.

EAGLE

"Chemi-Sealed"

(Super Bonded)

TURQUOISE

Drawing Pencils and Leads

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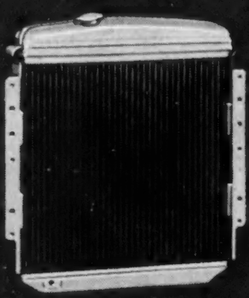
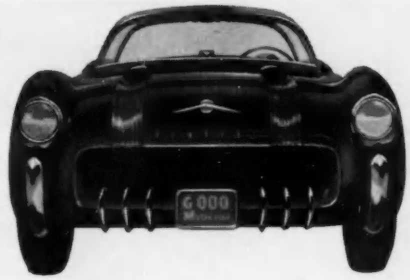
+ INDEX TO ADVERTISERS +

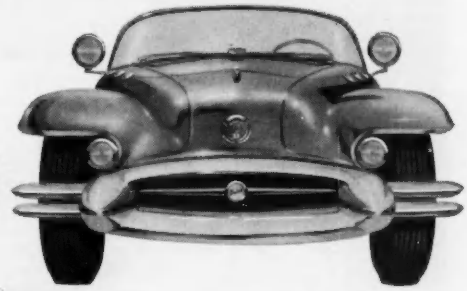
Cars of tomorrow... Harrison cooled!



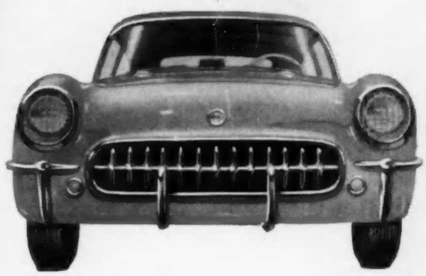
New ideas on wheels! And Harrison is keeping pace with these low, super-streamlined General Motors "dream cars". Behind each beautiful grille is a Harrison radiator . . . specially designed to cool the high-performance, high-powered engine. And no one is better equipped to design radiators for the cars of tomorrow than Harrison . . . leader in cooling the *cars of today*. For Harrison has the facilities . . . research, manufacturing, engineering! And Harrison has the *experience* . . . experience gained in the production of more than 57,000,000 radiators for cars, trucks and buses. If you have a cooling problem, look to Harrison for the answer!



BONNEVILLE . . . Low, sleek Pontiac features a plexiglass canopy over the driver compartment.

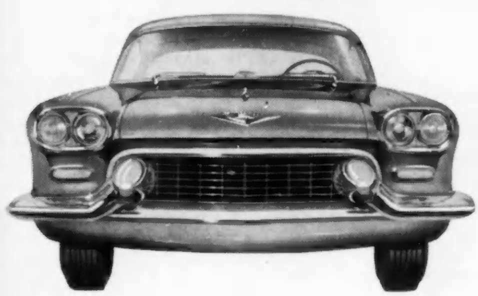


WILDCAT II . . . Sports convertible by Buick features "flying wing" front fenders.



CORVAIR . . . Exciting sports coupe by Chevrolet with "fast back" styling.

CUTLASS . . . Dynamo on wheels by Oldsmobile, with 250-h.p. "Rocket" Engine.



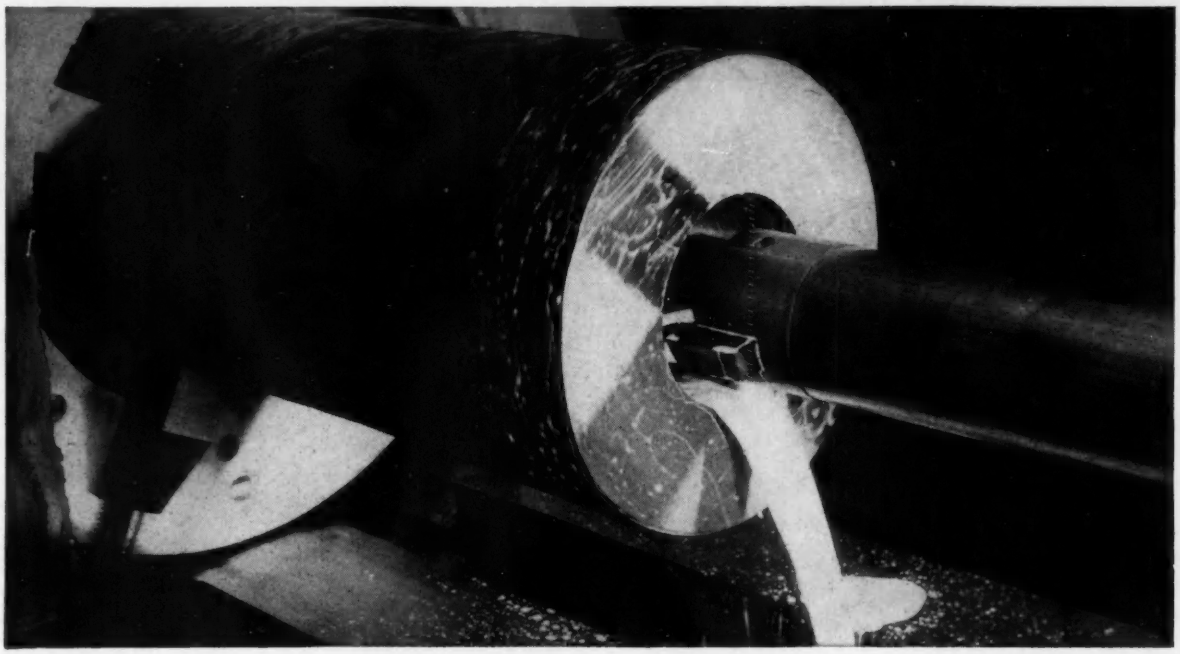
EL CAMINO . . . "Aircraft styling" gives Cadillac's "dream car" a rakish look of the future.

TEMPERATURES MADE TO ORDER

HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORPORATION, LOCKPORT, N. Y.

START WITH FINISH BORING!



TIMKEN® seamless steel tubing saves steel, machining time!

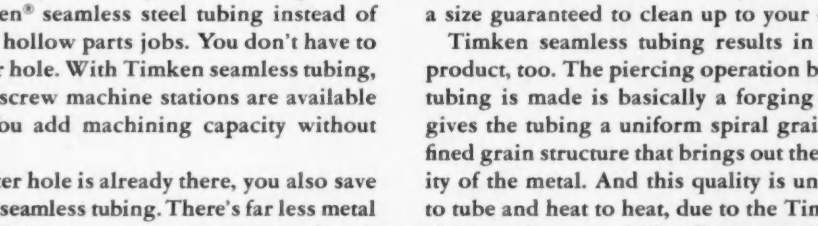
FINISH boring is your first production step when you use Timken® seamless steel tubing instead of bar stock for your hollow parts jobs. You don't have to bore out the center hole. With Timken seamless tubing, it's "built-in"! So screw machine stations are available for other jobs. You add machining capacity without adding machines.

Because the center hole is already there, you also save steel with Timken seamless tubing. There's far less metal to machine away, giving you more parts per ton of steel.

To save you even *more* steel, the Timken Company's engineers will study your problem and recommend the most economical tube size for your hollow parts job—a size guaranteed to clean up to your dimensions.

Timken seamless tubing results in a better quality product, too. The piercing operation by which Timken tubing is made is basically a forging operation. This gives the tubing a uniform spiral grain flow and a refined grain structure that brings out the best in the quality of the metal. And this quality is uniform from tube to tube and heat to heat, due to the Timken Company's rigid quality control. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING